Polyphasic taxonomy of *Aspergillus* section *Fumigati* and its teleomorph *Neosartorya*

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Abstract: The taxonomy of Aspergillus section *Fumigati* with its teleomorph genus *Neosartorya* is revised. The species concept is based on phenotypic (morphology and exトrolite profiles) and molecular (β-tubulin and calmodulin gene sequences) characters in a polyphasic approach. Four new taxa are proposed: *N. australensis*, *N. ferenczi*, *N. papuaensis*, and *N. warcupii*. All newly described and accepted species are illustrated. The section consists of 33 taxa: 10 strictly anamorphic *Aspergillus* species and 23 *Neosartorya* species. Four other *Neosartorya* species described previously were not available for this monograph, and consequently are relegated to the category of doubtful species.

**Taxonomic novelties:** *Neosartorya australensis*, *N. ferenczi*, *N. papuaensis*, *N. warcupii*

**Key words:** *Aspergillus* section *Fumigati*, exトrolite profiles, *Neosartorya*, phylogenetics, polyphasic taxonomy.

INTRODUCTION

*Aspergillus* section *Fumigati* includes species characterised by uniseriate aspergilli, columnar conidial heads in shades of green and flask shaped vesicles (Raper & Fennell 1965). Teleomorphic species belonging to the "*Aspergillus fischeri* series" of the *A. fumigatus* group (Raper & Fennell 1965) were placed in the genus *Neosartorya* (family Trichocomaceae) by Malloch & Cain (1972). *Section Fumigati* includes more than 20 *Neosartorya* species and 10 anamorphic species (Pitt et al. 2000; Samson 2000; Horie et al. 2003; Hong et al. 2005, 2006, 2007).

*Aspergillus fumigatus* Fresenius is an ubiquitous filamentous fungus in the environment, and also an important human pathogen (Raper & Fennell 1965). Several *Neosartorya* species have been described as causal agents of human diseases including invasive aspergillosis, osteomyelitis, endocarditis and mycotic keratitis (Coriglione et al. 1990; Summerbell et al. 1992; Padhye et al. 1994; Lonial et al. 1997; Jarv et al. 2004; Balajee et al. 2005, 2006). All of the *Neosartorya* species produce heat-resistant ascospores that are frequently encountered in different food products (Gomez et al. 1994; Samson 1989; Tourmas 1994). The several mycotoxins produced by these species may cause serious health hazard (Fujimoto et al. 1993; Frisvad & Samson 1990; Larsen et al. 2007). Some species also have valuable properties for mankind; e.g. *N. fischeri* strains produce fiscalin which effectively inhibit the binding of substance P to the human neurokinin receptor (Wong et al. 1993), while *A. fumigatus* strains produce pyrropropenone, potent inhibitors of acyl-CoA:cholesterol acytransferase (Tomoda et al. 1994), the immunosuppressant restrictocins (Müllbacher & Eichner 1984), ribotoxins (Lin et al. 1995) and fumagillin that has amebicidal activity (McCown et al. 1951). *Neosartorya spinosa* can be used for the complete enzymatic recovery of ferulic acid from corn residues (Shin et al. 2006).

Here we present an overview of the species belonging to *Aspergillus* section *Fumigati* based on analysis of macro- and micromorphology, exトrolite profiles and β-tubulin, calmodulin, ITS and actin gene sequences of the isolates. We also describe four new homothallic *Neosartorya* species found in soil samples in Australia and Papua New Guinea using this polyphasic approach and list synonymies.

MATERIALS AND METHODS

Source of microorganisms

The fungi examined included type strains or representatives of all species available for examination in *Aspergillus* section *Fumigati*. Some atypical isolates collected in Australia and Papua New-Guinea were also examined to clarify their taxonomic status (Table 1).

Morphology and physiology

The strains (Table 1) were grown for 7 d as 3-point inoculations on Czapek agar, Czapek yeast autolysate agar (CYA), oat meal agar (OA) and malt extract agar (MEA) plates at 25 °C, and on CYA at 37 °C. For *Neosartorya* species Hay infusion agar and SNA agar have also been used for inducing the anamorphs (medium compositions in Samson et al. 2004). In some species e.g. *N. tatenoi* the anamorph could only be produced when growing the cultures at 30 or 37 °C on MEA + 40 % sucrose.
Table 1. Aspergillus section Fumigati isolates used in this study.

| Species               | Isolate No.* | Source                                      |
|-----------------------|--------------|---------------------------------------------|
| A. brevipes           | CBS 118.53T  | Soil, Australia                             |
| A. duricaulis         | CBS 481.65T  | Soil, Buenos Aires, Argentina               |
| A. fumigati ispulnis  | IBT 12703T   | Soil, U.S.A.                                |
| A. fumigatus          | CBS 133.61T = NRRL 163 | Chicken lung, U.S.A.                     |
| A. fumisynnematus     | IFM 42277T   | Soil, Venezuela                             |
| A. lentulus           | CBS 117887T = NRRL 35552 = KACC 41940 | Man, U.S.A.                                |
| A. novofumigatus      | IBT 16806T   | Soil, Ecuador                               |
| A. unilateralis       | CBS 126.56T  | Rhizosphere, Australia                      |
| A. vindobonensis      | CBS 127.56T  | Rabbit dung, Australia                      |
| A. turcosus           | KACC 42090 = IBT 27920 | Air conditioner, Incheon, Korea          |
|                       | KACC 42091T = IBT 27921 | Air conditioner, Seoul, Korea            |
| N. assulata           | KACC 41691T  | Tomato soil, Buyeo, Korea                  |
| N. aurata             | CBS 466.65T  | Jungle soil, Brunei                        |
| N. aureola            | CBS 105.55T  | Soil, Tafo, Ghana                          |
| N. australensis sp. nov | CBS 112.55T = NRRL 2392 = IBT 3021 | Garden soil, Adelaide, Australia            |
| N. coreana            | KACC 41659T = NRRL 35950 = CBS 121594 | Tomato soil, Buyeo, Korea              |
| N. denticulata        | CBS 652.73T = KACC 41183 | Soil under Elaeis guineensis, Suriname |
|                       | CBS 290.74 = KACC 41175 | Acer pseudoplatanus, Netherlands |
| N. fennelliae         | CBS 598.74T  | Eye ball of Oryctolagus cuniculus, U.S.A.  |
| N. fennelii           | CBS 598.74  | Eye ball of Oryctolagus cuniculus, U.S.A.  |
| N. ferenczi sp. nov.  | CBS 121594T = IBT 27813 = NRRL 4179 | Soil, Australia                          |
| N. fischeri           | CBS 544.65T = NRRL 181 | Canned apples                          |
| N. galapagensis       | CBS 117522T = IBT 16756 = KACC 41935 | Soil, Ecuador                          |
|                       | CBS 117521 = IBT 16763 = KACC 41936 | Soil, Ecuador                          |
| N. glabra             | CBS 111.55T  | Rubber scab from old tire, Iowa, U.S.A.     |
| N. hiratsukae         | CBS 294.93T  | Aloe juice, Tokyo, Japan                    |
| N. lacinioca          | KACC 41657T = NRRL 35589 = CBS 117721 | Tomato soil, Buyeo, Korea             |
| N. multiplicata       | CBS 646.95T = IBT 17517 | Soil, Mouli, Taiwan          |
| N. nishimurae         | IFM 54133 = IBT 29024 | Forest soil, Kenya                        |
| N. nishimurae         | CBS 116047T | Cardboard, Netherlands                      |
| N. papuensis sp. nov. | CBS 841.96T = IBT 27801 | Bark of Podocarpus sp. (Podocarpaceae), bark, Myola, Owen Stanley Range, Northern Province, Papua New Guinea |
| N. pseudofischeri     | NRRL 20748T = CBS 208.92 | Human vertebrate, U.S.A.          |
| N. quadricincta       | CBS 135.52T = NRRL 2154 | Cardboard, York, U.K.                     |
|                       | CBS 107078  | Soil, Korea                                 |
|                       | CBS 100942 | Fruit juice, Netherlands                    |
|                       | CBS 253.94  | Canned oolong tea beverage, Japan (type strain of N. primulina) |
| N. spathulata         | CBS 408.89T  | Soil under Alocasia macrorhiza, Taiwan      |
| N. spinosa            | CBS 483.65T  | Soil, Nicaragua                             |
| N. stramenia          | CBS 498.65T  | Soil from maple-ash-eolm forest, Wisconsin, U.S.A. |
| N. taienoi            | CBS 407.93T  | Soil of sugarcane, Timbauba, Brazil         |
| N. utagawa            | CBS 114217T | Soil, Brazil                                |
|                       | CBS 114218 | Soil, Brazil                               |
| N. warcupii sp. nov.  | NRRL 35723T | Arid soil, Finder’s Range, Australia       |

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Analysis for extrolites

Extrolites were analysed using the HPLC-diole array detection method of Frisvad & Thrane (1987, 1993) as modified by Smidsgaard (1997). Extrolites were analyzed from cultures grown on CYA, OA and YES agar using three agar plugs (Smidsgaard 1997).

Isolation and analysis of nucleic acids

Isolates used for the molecular studies were grown on 2 mL of malt peptone broth [10 % (v/v) malt extract (Brix 10) and 0.1 % (v/v) bacto peptone (Difco)], in 15 mL tubes. The cultures were incubated at 25 °C for 7 d. DNA was extracted from the cells using the Masterpure™ yeast DNA purification kit (Epicentre Biotechnol.) following the instructions of the manufacturer. Fragments containing the ITS region were amplified using primers ITS1 and ITS4 as described (White et al. 1990). Amplification of partial β-tubulin gene was performed using the primers Bt2a and Bt2b and methods of Glass & Donaldson (1995). Amplifications of the partial calmodulin and actin genes were as described (Hong et al. 2005, 2007). Sequencing reactions were performed with the Big Dye Terminator Cycle Sequencing Ready Reaction Kit and carried out for both strands. All the sequencing reactions were purified by gel filtration through Sephadex G-50 (Amersham Pharmacia Biotech, Piscataway, NJ) equilibrated in double-distilled water and analyzed on the ABI PRISM 310 Genetic Analyzer (Applied Biosystems). The complementary sequences were corrected with the MT Navigator software (Applied Biosystems). Unique ITS, β-tubulin, actin and calmodulin sequences were deposited in GenBank (http://www.ncbi.nlm.nih.gov) with accession numbers DQ534140, DQ534141 and EU20279–EU220287.

Data analysis

Sequence alignments were performed using CLUSTAL-X (Thompson et al. 1997) and improved manually. The neighbour-joining (NJ) method was used for the phylogenetic analysis. For NJ analysis, the data were first analysed using the Tamura–Nei distance calculation with gamma-distributed substitution rates (Tamura & Nei 1993), which were then used to construct the NJ tree with MEGA v. 3.1 (Kumar et al. 2004). A bootstrap analysis was performed with 1 000 replications to determine the support for each clade. A bootstrap analysis was performed with 1 000 replications to determine the support for each clade.

PAUP v. 4.0 b10 software was used for parsimony analysis (Swofford 2002). Alignment gaps were treated as a fifth character state and all characters were unordered and of equal weight. Maximum parsimony analysis was performed for all data sets using the heuristic search option with random addition order (100 reps) and tree bisection-reconnection (TBR) branch-swapping algorithm. Branches of zero length were collapsed and all multiple, equally parsimonious trees were saved. The robustness of the trees obtained was evaluated by 1 000 bootstrap replications (Hillis & Bull 1993). Sequences from an A. clavatus isolate were used as outgroups in these experiments.

RESULTS AND DISCUSSION

Phylogenetic analysis

We examined the phylogenetic relatedness of species belonging to Aspergillus section Fumigati using sequence analysis of partial β-tubulin, calmodulin and actin genes including sequences of all known species. ITS sequences were determined from the new species and the species most closely related to them in the β-tubulin tree. The partial β-tubulin gene alignment included 453 characters. Among the polymorphic sites, 102 were found to be phylogenetically informative. The Neighbour-joining tree based on partial β-tubulin genes sequences is shown in Fig. 1. The topology of the tree is the same as one of the 419 maximum parsimony trees constructed by the PAUP programME (length: 465 steps, consistency index: 0.6710, retention index: 0.6467). The calmodulin data set included 549 characters with 85 parsimony informative characters. The Neighbour-joining tree shown in Fig. 2 has the same topology as one of the 9 maximum parsimony trees (tree length: 323, consistency index: 0.7585, retention index: 0.6422). The actin data set included 390 characters with 104 parsimony informative characters. The Neighbour-joining tree in Fig. 3 has the same topology as one of the 312 maximum parsimony trees (tree length: 397, consistency index: 0.6765, retention index: 0.7130). The ITS data set included 501 characters with 26 parsimony informative characters. The Neighbour-joining tree in Fig. 4 has the same topology as one of the 57 maximum parsimony trees (tree length: 77, consistency index: 0.7532, retention index: 0.7130).

The four Neosartorya isolates representing new species were found to be different from all known species of Aspergillus section Fumigati based on either their β-tubulin, calmodulin or actin gene sequences. However, one of them (NRRL 4179) had identical ITS sequences with N. denticulata (Fig. 4). This isolate was found to be closely related to a clade including N. fennelliae and N. denticulata on all other trees.

Possible synonyms of some species described previously have also been examined during this study. Based on multilocus sequence analyses Hong et al. (2007) discussed the synonymy of N. botucatensis, N. paulistensis and N. takaki with N. spinosa (Raper & Fennell) Kozak. (1972). N. spinosa and the synonyms have roughly circular arrangements of projections on the ascospore convex walls. N. spinosa produces echinulate ascospores with spines ranging from < 0.5 µm up to 5(–7) µm long with verruculose and small triangular projections or sometimes with circularly arranged projections.

N. otanii Takada, Y. Horie & Abliz (2001) was described on the basis of its rapid growth on Czapek and malt extract agars, lenticular ascospores with two widely separated equatorial crests, tuberculate or lobate-ridiculate convex surface, and globose to broadly ellipsoidal conidia with a microtuberculate wall. The morphology of N. otanii resembles N. fennelliae, although Takada et al. (2001) reported small differences of the ascospore ornamentation, which was not confirmed in our SEM studies. The β-tubulin gene sequences of N. otanii (GenBank accession numbers AB201363 and AB201362) were identical with N. fennelliae (KACC 42228) (Fig. 5A). These N. fennelliae isolates produced ascospores after mating with the N. fennelliae type strains (data not shown). N. otanii is probably synonymous with N. fennelliae, but mating experiments with N. fennelliae and N. otanii are needed for its confirmation.
Fig. 1. Neighbour-joining tree based on β-tubulin sequence data of *Aspergillus* section *Fumigati*. Numbers above branches are bootstrap values. Only values above 70 % are indicated.

Fig. 2. Neighbour-joining tree based on calmodulin sequence data of *Aspergillus* section *Fumigati*. Numbers above branches are bootstrap values. Only values above 70 % are indicated.
Fig. 3. Neighbour-joining tree based on actin sequence data of Aspergillus section Fumigati. Numbers above branches are bootstrap values. Only values above 70 % are indicated.

Fig. 4. Neighbour-joining tree based on ITS sequence data of selected species of Aspergillus section Fumigati. Numbers above branches are bootstrap values. Only values above 70 % are indicated.
Fig. 5A. Neighbour-joining tree based on β–tubulin sequences showing the relationship of *N. otanii* and *N. fennelliae*. B. Neighbour-joining trees based on β-tubulin, calmodulin and actin sequence data of *Neosartorya* spp. showing the relationship of *N. primulina*, *N. quadricincta*, *N. tatenoi* and *N. delicata*. 
These experiments could not be carried out because the ex type cultures of *N. otanii* were not available.

*Neosartorya primulina* Udagawa, Toyaz. & Tsub. (1993) was characterised by its restricted growth on Czapek agar, chalky-buff ascomata, and lenticular ascospores with a very irregular ornamentation composed of several narrow crests and verrucose hemispheres. The ascospore ornamentation and anamorph morphology resembles those of *N. quadricincta*. Furthermore, the ex type culture (CBS 253.94) of *N. primulina* showed nearly identical sequences with strains of *N. quadricincta* for β-tubulin, calmodulin and actin genes (Fig. 5B). Therefore, we consider *N. delicata* as a synonym of *N. quadricincta*.

*Neosartorya delicata* H.Z. Kong (1997) was described based on its ellipsoid or nearly clavate vesicles, and ascospores with conspicuous spines, joining one spine to another by fairly prominent ridges and reticulate ornamentation, the ridges spreading to the equatorial crests. This species has identical ascospore morphology with *N. tatenoi* (Fig. 36), and both taxa were clustered into a clade in three gene trees (99.6 % in β-tubulin, 98.5 % in calmodulin and 97.3 % in actin gene sequences) (Fig. 5B). Therefore, we consider *N. delicata* as a synonym of *N. tatenoi*.

*Neosartorya nishimurae* (Takada et al. 2001), *N. indohii*, *N. tsurutae* (Horie et al. 2003), *N. takakii* (Horie et al. 2001) and *N. sublevispora* (Someya et al. 1999) ex-type cultures were not available for this monograph of *Aspergillus* section *Fumigati*, and because we could not study them, they are listed as doubtful species.

### Table 2. Extrolites produced by species assigned to *Aspergillus* section *Fumigati*.

| Species                          | Extrolites produced                                                                 |
|----------------------------------|-------------------------------------------------------------------------------------|
| *Aspergillus brevipes*           | roquefortine C, meleagrin-like                                                   |
| *Aspergillus durieuxalis*        | pseurotin A, fumagillin, asperpentyn, durieuxalic acid and asperdulin, phthalides, |
|                                  | chromanols, cyclopalic acid, 3-O-methylcyclopalic acid                              |
| *Aspergillus fumigaftaffinis*    | auranthine, cycloechinuline, fumigacavines, helvolic acid, neosartorin, paltitant, |
|                                  | pyripyropenes A, E, O & S, tryptoquivaline, tryptoquivalone                           |
| *Aspergillus fumigatus*          | fumagillin, fumitoxins, fumigacavines A & C, fumitremorgins, glitoxit, trypacidin, |
|                                  | pseudotins, helvolic acid, pyripyropens, methyl-sulochrin, veruculogen, fumiquinazolines |
| *Aspergillus fumisynematus*      | neosartorin, pyripyropens, fimmycin                                               |
| *Aspergillus lentuluis*          | cycloazinic acid, pyripyropenes A & O, terrein, auranthine, neosartorin             |
| *Aspergillus novofumigatia*      | aszonalenin, cycloechinuline, fiscalins, helvolic acid, neosartorin, paltitant,     |
|                                  | terrein, terrein, terrein B                                                         |
| *Aspergillus turcosus*           | kotanins and several unique but not yet elucidated secondary metabolites            |
| *Aspergillus unilateralis*       | mycophenicolic acid, other unique secondary metabolites                             |
| *Aspergillus viridinutans*       | viriditoxin, 13-C-methylviriditoxin, phomaligun A, variotin, viriditin,             |
|                                  | wasabidienone B0, B1, B1, viriditin, 4-acetyl-6,8-dihydroxy-5-methyl-2-benzopyran-1-|
|                                  | 1-A                                                                                |
| *Neosartorya assulata*           | indole alkaloids and apolar metabolites                                            |
| *Neosartorya aurata*             | helvolic acid, yellow unidentified compounds                                         |
| *Neosartorya aureola*            | fumagillin, tryptoquivalone, pyripyropen, pseudotin A and viriditoxin (FRR 2269 also produces helvolic acid) |
| *Neosartorya australensis*       | wortmannin-like, aszonalenin-like                                                  |
| *Neosartorya coreana*            | aszonalenins                                                                        |
| *Neosartorya denticulata*        | glitoxitin, viriditoxin                                                            |
| *Neosartorya fennelliae*         | asperfurans, aszonalenin, fumigacavine, viriditamotxin                             |
| *Neosartorya feroxii*            | asperfurans, aszonalenin, fumigacavine, viriditamotxin, glitoxitin-like, fumigatins, |
|                                  | aszonalenin-like                                                                    |
| *Neosartorya fischeri*           | terrein, fumitremorgins A & C, tryptoquivaline A, trypacidin, TR-2, fumiquinazolines, |
|                                  | sarpacin, aszonalenins, fischerin, neosartorin, fiscalins, helvolic acid             |
| *Neosartorya galapagensis*       | wortmannin-like                                                                    |
| *Neosartorya glibra*             | asperpentyn, avenaciolide, wortmannin-like compound                                |
| *Neosartorya hiratsukae*         | avenaciolide                                                                        |
| *Neosartorya laciniosa*          | aszonalenins, tryptoquivaline, tryptoquivalone                                      |
| *Neosartorya multiplica*         | helvolic acid                                                                       |
| *Neosartorya papuensis*          | wortmannin-like                                                                    |
| *Neosartorya pseudofischeri*     | asperfurans, cytochilasmin-like compound, fiscalin-like compound, pyripyropens,     |
|                                  | glitoxitin                                                                         |
| *Neosartorya quadricincta*       | quinolactacin, aszonalenin                                                         |
| *Neosartorya spinosa*            | aszonalenins, 2-pyroyovalaminobenzamide, pseudotin                                 |
| *Neosartorya spathulata*         | xanthocilians, aszonalenins                                                        |
| *Neosartorya stramenia*          | quinolactacin, avenaciolide                                                        |
| *Neosartorya tatenoi*            | aszonalenins                                                                        |
| *Neosartorya udagawae*           | fumagalin, fumagillin, tryptoquivaline, pyripyropen                                |
| *Neosartorya warcupii*           | wortmannin-like, aszonalenin-like, chromanols-like, tryptoquivaline-like and tryptoquivalene-like |
Morphology and extrolate production

The atypical *N. glabra* isolate NRRL 4179 (Raper & Fennell 1965) produced asperfuran, aszonalenin, fumigaclavine, viridicataumtoxin, and fumigatins, extrolites common in *N. fennelliae*, but none of the extrolites produced by *N. glabra*. However, in contrast with the heterothallic *N. fennelliae*, this isolate is homothallic. It is closely related to *N. denticulata* based on phylogenetic analysis of sequence data, although their ascospore ornamentations are strikingly different (Figs. 21, 23). Ascospore ornamentation of NRRL 4179 is similar to that of the heterothallic *N. fennelliae* (Fig. 22) with equatorial crests much narrower, while *N. denticulata* has denticulate ascospores without equatorial crests. Isolate NRRL 4179 exhibited 72% nuclear DNA relatedness to *N. fennelliae* and only 60% relatedness to *N. glabra* isolates (Peterson 1992). This isolate also yielded different mtDNA and Smal-digested repetitive DNA patterns from those of all the other *Neosartorya* strains examined (Rinyu et al. 2000). Hybridisation experiments were also carried out with *Neospora crassa* mating type genes (the A idiomorph with about 6 kb flanking sequences, or the A idiomorph flanked by about 2 kb genomic DNA on either side) to the EcoRI digested DNA of several teleomorphic and asexual *Aspergillus* strains. Hybridisation to a 1.9 kb band was observed for both mating-type strains of *N. fennelliae* and isolate NRRL 4179 (Rinyu et al. 2000). Based on these observations, isolate NRRL 4179 seems to be closely related to *N. fennelliae* strains. These results are in agreement with those found using carbon source utilisation tests and isoenzyme analysis of these strains (Varga et al. 1997).

Strain NRRL 35723 was isolated from soil in Australia, and produced compounds structurally related to wortmannin, aszonalenin, chromanols, tryptoquivalins and tryptoquivalons. This isolate was markedly different from all other known *Neosartorya* species. Strain NRRL 35723 was isolated from soil in Australia, and produced compounds similar to wortmannin and aszonalenin and some unique metabolites, while CBS 841.96 was isolated from *Podocarpus* bark in Papua New Guinea, and produced a compound related to wortmannins and some unique compounds the structures of which have not yet been elucidated (Table 2). The ascospore ornamentations of these isolates were microtuberculate, similarly to those of *N. glabra* and *N. galapagensis*. However, both isolates produced cream-coloured colonies on CYA in contrast with *N. glabra* which produces greyish green colonies. In phylogenetic analysis they were unrelated to any other *Neosartorya* species, justifying their treatment as new species. We propose four new homothallic and monotypic *Neosartorya* species; *N. ferenczii* (NRRL 4179), *N. warcupii* (NRRL 35723), *N. australensis* (CBS 112.55) and *N. papuensis* (CBS 841.96).

Identification

Traditionally the identification of members of section *Fumigati* were done using the colony patterns and the morphology of the conidigenous structures, conidia, ascospores and extrolites. Ascospore ornamentation has been studied by Scanning electron microscopy, but our studies have shown that different species have similar extrolate shape and surface structure. Several species such *A. fumigatus*, *A. novofumigatus*, *fumigatiaffinis*, *A. fumisynnematus* and *A. lentulus* show strong morphological resemblance and in the light microscope these species can be difficult to be separated. The anamorphs of *Neosartorya udagawae* and *N. fennelliae* also show a similar morphology. Therefore we recommend that for a correct species identification, sequence analysis should be carried out. Our experience with sequencing the calmodin and β-tubulin gene revealed good species delimitation and recognition. All sequences of the ex type cultures of section *Fumigati* are available from specialised databases and also from GenBank.

List of accepted species belonging to *Aspergillus* section *Fumigati*

The list of known species of *Neosartorya* and anamorphic species from the section *Fumigati* (Horie et al. 2003; Hong et al. 2005, 2006, 2007) is still expanding. With the species proposed here, there are now 23 *Neosartorya* species (including four new taxa) and 10 *Aspergillus* species in this group, 33 species in total and they are illustrated below.

Strict anamorphic species:

*Aspergillus brevipes* Smith
*Aspergillus duricaulis* Raper & Fennell
*Aspergillus fumigatiaffinis* Hong, Frisvad & Samson
*Aspergillus fumigatus* Fresenius
  - *A. anomalus* Pidoplichko & Kirilenko
  - *A. fumigatus* var. *acoluminaris* Rai et al.
  - *A. fumigatus* var. *ellipticus* Raper & Fennell
  - *A. fumigatus* mut. *helvola* Rai et al.
  - *A. phialiseptus* Kwon-Chung
  - *A. neellipticus* Kozakiewicz
  - *Aspergillus arvi* Aho, Horie, Nishimura & Miyaji
*Aspergillus fumisynnematus* Horie, Miyaji, Nishimura, Taguchi & Udagawa
*Aspergillus lentulus* Balajee & Marr
Aspergillus novofumigatus Hong, Frisvad & Samson
Aspergillus turcosus Hong, Frisvad & Samson
Aspergillus unilateralis Thrower
≡ A. brevipes var. unilateralis (Thrower) Kozakiewicz
Aspergillus viridinutans Ducker & Thrower
≡ A. fumigatus var. sclerotiorum Rai, Agarwal & Tewari

Teleomorph species:

Neosartorya assulata Hong, Frisvad & Samson [anamorph: A. assulatus Hong, Frisvad & Samson]
Neosartorya aurata (Warcup) Malloch & Cain [anamorph: A. igneus Kozakiewicz]
Neosartorya aureola (Fennell & Raper) Malloch & Cain [anamorph: A. aureoluteus Samson & Gams]
Neosartorya australiensis Samson, Hong & Varga, sp. nov.
Neosartorya coreana Hong, Frisvad & Samson [anamorph: A. coreanus Hong, Frisvad & Samson]
Neosartorya denticulata Samson, Hong & Frisvad [anamorph: A. denticulatus Samson, Hong & Frisvad]
Neosartorya fennelliae Kwon-Chung & Kim [anamorph: A. fennelliae Kwon-Chung & Kim]
Neosartorya ferenczii Varga & Samson, spec. nov.
Neosartorya fischeri (Wehmer) Malloch & Cain [anamorph: A. fischeranus Kozakiewicz]
Neosartorya galapagensis Frisvad, Hong & Samson [anamorph: A. galapagensis Frisvad, Hong & Samson]
Neosartorya glabra (Fennell & Raper) Kozakiewicz [anamorph: A. neoglaber Kozakiewicz]
Neosartorya hiratsukae Udagawa, Tsubouchi & Horie [anamorph: A. hiratsukae Udagawa, Tsubouchi & Horie]
Neosartorya laciniosa Hong, Frisvad & Samson [anamorph: A. laciniosus Hong, Frisvad & Samson]
Neosartorya multiplicata Yaguchi, Someya & Udagawa [anamorph: A. multiplicatus Yaguchi, Someya & Udagawa]
Neosartorya papuensis Samson, Hong & Varga, sp. nov.
Neosartorya pseudofischeri Peterson [anamorph: A. thermomutatus (Paden) Peterson]
Neosartorya quadricincta (Yuill) Malloch & Cain [anamorph: A. quadricingens Kozakiewicz]
≡ Neosartorya primulina Udagawa, Toyazaki & Tsubouchi [anamorph: A. primulinus Udagawa, Toyazaki & Tsubouchi]
Neosartorya spinosa (Raper & Fennell) Kozakiewicz [anamorph: A. spinosus Kozakiewicz]
≡ Aspergillus fischeri var. spinosus Raper & Fennell 1965 (basionym)
= Sartorya fumigata var. verrucosa Udagawa & Kawasaki
≡ Neosartorya botucatensis Horie, Miyaji & Nishimura [anamorph: A. botucatensis Horie, Miyaji & Nishimura]
≡ Neosartorya paulistensis Horie, Miyaji & Nishimura [anamorph: A. paulistensis Horie, Miyaji & Nishimura]
? = Neosartorya takakii Horie, Abliz & Fukushima [anamorph: A. takaki Horie, Abliz & Fukushima]
Neosartorya spathulata Takada & Udagawa [anamorph: A. spathulatus Takada & Udagawa]
Neosartorya stramenia (Novak & Raper) Malloch & Cain [anamorph: A. paleaceus Samson & Gams]
Neosartorya tatenoi Horie, Miyaji, Yokoyama, Udagawa & Campos-Takagi [anamorph: A. tatenoi Horie, Miyaji, Yokoyama, Udagawa & Campos-Takagi]
≡ Neosartorya delicata Kong [anamorph: A. delicatus Kong]
Neosartorya udagawae Horie, Miyaji & Nishimura [anamorph: A. udagawae Horie, Miyaji & Nishimura]
Neosartorya warcupii Peterson, Varga & Samson, sp. nov.

Doubtful species:

Neosartorya sublevispora Someya, Yaguchi & Udagawa [anamorph: A. sublevisporus Someya, Yaguchi & Udagawa]
Neosartorya indohii Horie [anamorph: A. indohii Horie]
Neosartorya tsurutae Horie [anamorph: A. tsurutae Horie]
Neosartorya nishimurae Takada, Horie & Abliz [anamorph: A. nishimurae Takada, Horie & Abliz]
Aspergillus brevipes Smith, Trans. Br. mycol. Soc. 35: 241. 1952. Fig. 6.

Type: CBS 467.91, from soil, New South Wales, Australia

Other no. of the type: ATCC 16899; CBS 118.53; IFO 5821; IMI 16034; IMI 51494; NRRL 2439; WB 4772 = IBT 22571; WB 4078 = IBT 22572

Description
Colony diam (7 d): CYA25: 12–15 mm; MEA25: 30–34 mm; YES25: 23–25 mm; OA25: 28–33 mm; CYA37: 16–19 mm; CREA: weak growth, no acid production
Colony colour: purple red
Conidiation: abundant
Reverse colour (CZA): dull yellow turning to reddish brown
Colony texture: velutinous
Conidial head: short columnar
Stipe: 15–50 (–100) µm, occasionally septate, heavy walled
Vesicle diam, shape: 10–18 µm, pear shaped
Conidium size, shape, surface texture: 2.8–3.5 µm, globose, spinulose

Cultures examined: CBS 467.91; WB 4772; WB 4078; CBS 118.523 = IBT 3051, all from the same original source

Diagnostic features: short heavy walled stipes, finely spinulose conidia, purple red colony colour, coloured vesicles and phialides and dark blue conidia; characterised by its vesicles borne at an angle to the stipe, as in A. viridinutans and A. duricaulis

Similar species: A. duricaulis

Distribution: Australia

Ecology and habitats: soil

Aspergillus duricaulis Raper & Fennell, The genus Aspergillus, 249. 1965. Fig. 7.

Type: CBS 481.65, from soil, Buenos Aires, Argentina

Other no. of the type: ATCC 16900; IMI 172282; JCM 01735; IBT 23177; NRRL 4021; VKM F-3572; WB 4021

Description
Colony diam (7 d): CYA25: 21–25 mm; MEA25: 20–22 m; YES25: 40–44 mm; OA25: 40–44 mm, CYA37: 21–25 mm; CREA: poor growth, no acid production
Colony colour: lily green to slate olive
Conidiation: limited
Reverse colour (CZA): colourless to pinkish drab
Colony texture: floccose
Conidial head: short columnar
Stipe: 5–8 µm in diam.
Vesicle diam, shape: 7–18 µm, globose-subglobose
Conidium size, shape, surface texture: 2–3 µm, globose-subglobose, smooth

Diagnostic features: has comparatively small (sub)globose vesicles (16–24 µm); able to grow at 10 °C, and unable to grow at 50 °C

Similar species: A. fumigatus, A. lentulus, A. novofumigatus, A. fumigatiaffinis

Distribution: U.S.A., Spain

Ecology and habitats: kangaroo rat, soil, human

Extralites: auranthine, cycloechinuline, fumigaclavines, helvolic acid, neosartorin, palitantin, pyripyropenes A, E, O & S, tryptoquivaline, tryptoquivalone

Pathogenicity: pathogenic to humans (Alcazar-Fuoli et al. 2007)

Aspergillus fumigatiaffinis Hong, Frisvad & Samson, Mycologia 97: 1326. 2005. Fig. 8.

Type: CBS 117186, from soil, Socorro County, Sevilleta National Wildlife Refuge, New Mexico, U.S.A..

Other no. of the type: KACC 41148; IBT 12703

Description
Colony diam (7 d): CYA25: 46–49 mm; MEA25: 53–60 mm; YES25: 67–74; CYA37: 65–70; CREA: weak growth, good acid production
Colony colour: white, with center dull green
Conidiation: limited
Reverse colour (CZA): yellowish to greyish orange
Colony texture: floccose
Conidial head: short columnar
Stipe: 6–8 µm in diam.
Vesicle diam, shape: 18–24 µm, globose-subglobose
Conidium size, shape, surface texture: 2–3 µm, globose-subglobose, smooth

Diagnostic features: has comparatively small (sub)globose vesicles (16–24 µm); able to grow at 10 °C, and unable to grow at 50 °C

Similar species: A. fumigatus, A. lentulus, A. novofumigatus, A. fumigatiaffinis

Distribution: U.S.A., Spain

Ecology and habitats: kangaroo rat, soil, human

Extralites: auranthine, cycloechinuline, fumigaclavines, helvolic acid, neosartorin, palitantin, pyripyropenes A, E, O & S, tryptoquivaline, tryptoquivalone

Pathogenicity: pathogenic to humans (Alcazar-Fuoli et al. 2007)

Note: exhibits high MICs to amphotericin B and several triazoles (Alcazar-Fuoli et al. 2007)
Fig. 6. *Aspergillus* brevipes. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C–I. Conidiophores. J. Conidia. Scale bars = 10 µm.
Fig. 7. Aspergillus duricaulis. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C–H. Conidiophores. I. Conidia. Scale bars = 10 μm.
Fig. 8. Aspergillus fumigatiaffinis. A–C. Colonies 7 d 25 °C. A. CYA. B. MEA 25 °C. C. MEA 37 °C. D–H. Conidiophores. I. Conidia. Scale bars = 10 µm.
**Aspergillus fumigatus** Fresenius, Beitr. Mykol. 81: 18. 1863. Fig. 9.
- Aspergillus fumigatus var. acolumnans Rai, Agarwal & Tewari (1971)
- Aspergillus fumigatus var. albus Rai, Tewari & Agarwal (1974)
- Aspergillus fumigatus var. celluloseae Sartory, Sartory & Mey. (1935)
- Aspergillus fumigatus var. conoideus Maichewr. (1939)
- Aspergillus fumigatus var. ellipicosus Raper & Fennell (1965)
- Aspergillus fumigatus var. fumigatus, Tewari & Agarwal (1974)
- Aspergillus fumigatus var. fumigatus Fresen. (1863)
- Aspergillus fumigatus giseirebrunneus var. Rai & Singh (1974)
- Aspergillus fumigatus var. helvolus Yuli (1937)
- Aspergillus fumigatus var. lundzinense Svilh. (1941)
- Aspergillus fumigatus var. minutus Sartory (1919)
- Aspergillus neoeolipicus Kozak. (1989)
- Aspergillus phialocephalus Kwon-Chung (1975)
- Aspergillus bronchialis Blumentritt (1901)
- Aspergillus septatus Sartory & Sartory (1943)
- Aspergillus anii Aho, Horie, Nishimura & Miyaji (1994)

**Type**: IMI 016152, from chicken lung, Connecticut, U.S.A.

**Other no. of the type**: Thom 118; QM 1981; WB 163; CBS 133.61; NRRL 163; ATCC 1022; LSHB Ac71; NCTC 982; KACC 41143

**Description**
- Colony diam (7 d): CYA25: 21–67 mm; MEA25: 25–69 mm; YES25: 42–80 mm; OA25: 34–62 mm; CYA37: 54–70 mm, CREA: poor growth, no or very weak acid production
- Colony colour: greyish turquoise or dark turquoise to dark green to dull green
- Weak growth, no acid production
- Other no. of the type: Thom 118; QM 1981; WB 163; CBS 133.61; NRRL 163; ATCC 1022; LSHB Ac71; NCTC 982; KACC 41143

**Cultures examined**: ATCC 32722, AF71, AF 293, AF294, CBS 112389, CBS 487.65, CBS 133.61, CBS 545.65, CBS 457.75, CBS 542.75, CBS 113.26, CBS 110.46, CBS 120.53, CBS 132.54, CBS 123.59, CBS 158.71, CBS 180.76, CBS 148.89, CBS 488.90, CBS 287.95, CBS 100076, CBS 109032, CBS 386.75, CBS 286.95, CEA10, IMI 376380, NRRL 1979

**Diagnostic features**
- Rapid growing velutinous colonies, abundant and fast conidiation, thick stipe (ca. 6–10 μm), large pyriform to subclavate, sometimes subglobose, but rarely globose
- Conidia length, shape, surface texture: 2–3.5(–6) μm, globose to subglobose, but rarely globose
- Vesicle diam, shape: 10–26 μm, pyriform to subclavate, sometimes subglobose, but rarely globose
- Colonia texture: floccose
- Conidial head: short columnar
- Stipe: 210 × 6–10(–10) μm
- Vesicle diam, shape: 16–20(–25) μm, hemispherical
- Conidium size, shape, surface texture: 2.8–3.2 × 2.4–2.8 μm, broadly ellipsoidal, verruculose

**Cultures examined**: IFM 42277

**Diagnostic features**: production of synnemata on MEA with age (1.4–2.3 mm in height, 30–40 μm in diam.)

**Similar species**: A. fumigatus, A. lentulus, A. novofumigatus, A. fumigatiaffinis

**Distribution**: Brazil, Venezuela, Spain

**Ecology and habitats**: soil, human

**Extrrolites**: fumagillin, fumitoxins, fumigaclavines A & C, fumitremorgins, fumiquinazolines, gliotoxin, helvolic acid, pseurotins, pyripyropens, methyl-sulochrin, trypadicin, verruculogen

**Pathogenicity**: pathogenic to humans (Raper & Fennell 1965; Marr et al. 2002)

**Note**: no growth at 10 °C, growth at 50 °C; some isolates carry dsRNA mycoviruses (Anderson et al. 1996)

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**Aspergillus fumisynnematus** Horie, Miyaji, Nishimura, Taguchi et Udagawa, Trans. Mycol. Soc. Japan: 34: 3–7. 1993. Fig. 10.

**Type**: IFM 42277, from soil, Sabaneta, Coro City, Falcon State, Venezuela

**Description**
- Colony diam (7 d): CYA25: 44–48 mm; MEA25: 56–60 mm; YES25: 35–39 mm; OA25: 42–46; CYA37: 57–61 mm, CREA: poor growth and no acid production
- Colony colour: greenish grey
- Conidiation: limited
- Reverse colour (CZA): orange white to orange grey
- Colony texture: floccose
- Conidial head: short columnar
- Stipe: 210 × 6–8.5(–10) μm
- Vesicle diam, shape: 16–20(–25) μm, hemispherical
- Conidium size, shape, surface texture: 2.8–3.2 × 2.4–2.8 μm, broadly ellipsoidal, verruculose

**Cultures examined**: IFM 42277

**Diagnostic features**: production of synnemata on MEA with age (1.4–2.3 mm in height, 30–40 μm in diam.)

**Similar species**: A. fumigatus, A. lentulus, A. novofumigatus, A. fumigatiaffinis

**Distribution**: Brazil, Venezuela, Spain

**Ecology and habitats**: soil, human

**Extrrolites**: fumagillin, fumitoxins, fumigaclavines A & C, fumitremorgins, fumiquinazolines, gliotoxin, helvolic acid, pseurotins, pyripyropens, methyl-sulochrin, trypadicin, verruculogen

**Pathogenicity**: pathogenic to humans (Alcazar-Fuoli et al. 2007; Yaguchi et al. 2007)

**Note**: growth at 10 °C, no growth at 50 °C

**Aspergillus lentulus** Balajee & Marr, Eukaryot. Cell 4: 631.2005. Fig. 11.

**Type**: FH5, from clinical specimens of patients hospitalised at the Fred Hutchinson Cancer Research Center, U.S.A.

**Other no. of the type**: KACC 41940, NRRL 35552; IBT 27201

**Description**
- Colony diam: CYA25: (19–)25–56 mm, MEA25: (30)40–70 mm; YES25: 35–39 mm; OA25: 42–46; CYA37: 57–61 mm, CREA: poor growth and no acid production
- Weak growth, no acid production
- Other no. of the type: KACC 41940, NRRL 35552; IBT 27201

**Diagnostic features**: Rapid growing velutinous colonies, abundant and fast conidiation, thick stipe (ca. 6–10 um), large pyriform to semi-clavate vesicle is representative morphological features of the species. However, the characteristics are various according to strains, and some strains have exceptional characteristics. The species grows at 50 °C, no growth at 10 °C.

**Similar species**: A. fumigatiaffinis, A. fumisynnematus, A. lentulus, A. novofumigatus, A. viridinutans.

**Distribution**: Worldwide distribution, cosmopolitan fungus (Pringle et al. 2005)

**Ecology and habitats**: soil, human

**Extrrolites**: fumagillin, fumitoxins, fumigaclavines A & C, fumitremorgins, fumiquinazolines, gliotoxin, helvolic acid, pseurotins, pyripyropens, methyl-sulochrin, trypadicin, verruculogen

**Pathogenicity**: pathogenic to humans (Raper & Fennell 1965; Marr et al. 2002)
Fig. 9. *Aspergillus fumigatus*. A–C. Colonies 7 d 25 °C. A. CYA. B. MEA. C. CYA 37 °C. after 3 d. D–I. Conidiophores. D–F. *A. fumigatus*. G–H. *A. fumigatus* var. ellipticus. I. Atypical conidiophore of CBS 133.61. J. Conidia of *A. fumigatus* var. ellipticus. K. Conidia of *A. fumigatus*. Scale bars = 10 µm.
Fig. 10. Aspergillus fumiynematatus. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C–H. Conidiophores. I. Conidia. Scale bars = 10 µm.
Fig. 11. Aspergillus lentulus. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C. Macroscopic view of the columnar conidial heads. D–I. Conidiophores. J. Conidia. Scale bars = 10 µm.
Conidia length, shape, surface texture: 2.0–3.2 µm, globose to broadly ellipsoidal, smooth to finely roughened

**Cultures examined:** KACC 41391 = CBS 116886, KACC 41392, KACC 41393, KACC 41681, KACC 41682, KACC 41642, KACC 41394, KACC 41395, KACC 41939 = FH7 = IBT 27209, KACC 41941 = FH4 = IBT 27210, KACC 41942 = FH220 = IBT 27202, KACC 41940 = FH5 = IBT 27201 = NRRL 35552

**Diagnostic features:** slow and poor conidiation, floccose colony texture, short columnar conidial heads, thin stipe (<7 µm), globose vesicle; growth at 10 °C and no growth at 50 °C

**Similar species:** A. fumigatiaffinis, A. fumigatus, A. fumisynnematus, A. novofumigatus, A. viridinutans

**Distribution:** Korea, U.S.A., Japan, Australia, Netherlands, Spain etc. It is assumed that the species is distributed worldwide.

**Ecology and habitats:** soil, human, dolphin

**Extrites:** cyclopiazonic acid, pyripyropenes A, E & O, terrein, auranthine, neosartorin

**Pathogenicity:** pathogenic to humans (Balajee et al. 2005b; Alhambra et al. 2006; Alcazar-Fuoli et al. 2007; Yaguchi et al. 2007; Lau et al. 2007)

**Note:** exhibits high MICs to amphotericin B and several triazoles (Balajee et al. 2004, 2005b)

**Aspergillus novofumigatus** Hong, Frisvad & Samson, Mycologia 97: 1326. 2005.

**Fig. 12.**

**Type:** CBS 117520, from soil, Galapagos Islands, Ecuador

**Other no. of the type:** IBT 16806

**Description**
Colony diam (7 d): CYA25: 33–48 mm; MEA25: 48–60 mm; YES25: 44–55 mm; OA25: 54–67 mm; CYA37: 49–52 mm; CREA: weak growth, no acid production

Colony colour: deep green to grey green

Conidiation: in central areas

Reverse colour (CZA): greyish orange to yellowish orange

Colony texture: velutinous

Conidial head: short columnar

Stipe: 50–500 × 4–7 µm in diam

Vesicle diam, shape: (13–)15–30 µm subglobose to flask shaped

Conidium size, shape, surface texture: 2.5–3 µm, ellipsoidal, smooth

**Cultures examined:** CBS 117520 = IBT 16806, CBS 117519 = IBT 16755

**Diagnostic features:** has nearly flask-shaped and comparatively large vesicles (15–30 mm); growth at 10 °C, no growth at 50 °C

**Similar species:** A. fumigatus, A. lentulus, A. fumisynnematus, A. novofumigatus, A. viridinutans

**Distribution:** Galapagos Islands, Ecuador

**Ecology and habitats:** soil

**Extrites:** aszonalenin, cycloechinuline, fiscalins, helvolic acid, neosartorin, palitantin, terrein, territrem B

**Pathogenicity:** not reported

**Aspergillus turcosus** Hong, Frisvad & Samson, Antonie van Leeuwenhoek (in press). 2005.

**Fig. 13.**

**Type:** KACC 42091, from air conditioner, Seoul, South Korea

**Other no. of the type:** IBT 27921

**Description**
Colony diam: CYA25: 32–41 mm; MEA25: 42–53 mm; YES25: 48–52 mm; OA25: 46–52 mm; CYA37: 48–56; CREA poor growth, no acid production

Colony colour: grey-turquoise to grey-green

Conidiation: abundant

Reverse colour (CZA): yellowish orange to greyish orange

Colony texture: velutinous

Conidial head: short columnar

Stipe: 80–100 × 4–7 µm

Vesicle diam, shape: 15–25 µm, flask shaped to globose

Conidium size, shape, surface texture: 2.5–3.5 µm, subglobose, smooth

**Cultures examined:** KACC 42091 = IBT 27921, KACC 42090 = IBT 27920, KACC 41955 = IBT 3016

**Diagnostic features:** Velutinous colony, grey-turquoise (green) colony colour and yellowish orange reverse on MEA and CYA, phialides cover distal two-thirds of the vesicle and growth at both 10 and 50 °C

**Similar species:** -

**Ecology and habitats:** air conditioner

**Distribution:** South Korea

**Extrites:** Kotanins and several unique compounds but not yet elucidated secondary metabolites

**Pathogenicity:** not reported

**Aspergillus unilateralis** Thrower, Austral. J. Bot. 2: 355. 1954.

**Fig. 14.**

≡ A. brevipes var. unilateralis (Thrower) Kozakiewicz

**Type:** CBS 126.56, from rhizosphere of Hibbertia fasciculata and Epacris impressa, Australia

**Other no. of the type:** ATCC 16902; IFO 8136; IMI 062876; NRRL 577, QM 8163; WB 4366; WB 4779; IBT 3210

**Description**
Colony diam: CYA25: 30 mm; MEA25: 60–70 mm in 14 d, CREA poor growth, no acid production

Colony colour: slate olive

Conidiation: in central areas

Reverse colour (CZA): nearly black

Colony texture: thin, brittle, folded in central area

Conidial head: diminutive, with few divergent spore chains

Stipe: 5–30 × 1.2–2.2 µm

Vesicle diam, shape: 4–8.5 µm, irregularly globose

Conidium size, shape, surface texture: 2.5–3.5 µm, globose, coarsely echinulate

**Cultures examined:** CBS 126.56; CBS 183.66 = IBT 3211
Fig. 12. *Aspergillus novofumigatus*. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C–H. Conidiophores. I. Conidia. Scale bars = 10 µm.
Fig. 13. Aspergillus turcosus. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C–I. Conidiophores. J. Conidia. Scale bars = 10 µm.
Fig. 14. Aspergillus unilateralis. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C. Macroscopic view of the conidial heads. D–I. Conidiophores. J. Conidia. Scale bars = 10 µm.
Diagnostic features: phialides clustered on one side of the vesicle, echinulate conidia, slow growth rate and dark reverse on CYA

Similar species: -

Distribution: Australia

Ecology and habitats: soil

Extrolites: mycophenolic acid, other unique secondary metabolites

Pathogenicity: not reported

Aspergillus viridinutans Ducker & Thrower, Austral. J. Bot. 2: 355. 1954. Fig. 15.

= A. fumigatus var. sclerotiorum J.N. Rai, S.C. Agarwal & J.P. Tewari

Type: CBS 127.56, from dung of rabbit, Frankston, Victoria, Australia

Other no. of the type: ATCC 16901; IMI 062875; IMI 062875ii; NRRL 4365; WB 4081; WB 4782; WB 4365

Description
Colony diam (7 d): CYA25: 20–40 mm; MEA25: 11–15 mm; YES25: 24–28 mm; OA25: 29–31 mm; CYA 37: 25–28 mm; CREA: poor growth, no acid production
Colony colour: Niagara green
Conidiation: limited on CZA, abundant on MEA
Reverse colour: colourless (CZA), yellowish green to light brownish olive (MEA)
Colony texture: centre raised, velutinous on MEA
Conidial head: columnar
Stipe: 20–35 × 3.3–4.4 µm
Vesicle diam, shape: 7.5–12 µm, flask shaped to subglobose
Conidium size, shape, surface texture: 2–2.8 µm, globose, delicately roughened

Cultures examined: CBS 127.56

Diagnostic features: “nodding” conidial heads, Niagara green colony colour

Similar species: none

Ecology and habitats: soil, dung, human

Distribution: Australia, Sri Lanka, Zambia, Russia (Varga et al. 2000b)

Extrolites: viriditoxin, 13-O-methylviriditin, phomalin A, variotin, viriditin, wasabidienone B0, B1, viriditin A (Omolo et al. 2000), 4-acetyl-6,8-dihydroxy-5-methyl-2-benzopyran-1-1 A (Aldridge et al. 1966)

Pathogenicity: pathogenic to humans (Katz et al. 2005, Yaguchi et al. 2007, Alcazar-Fuoli et al. 2007)

Notes: this is a highly variable species; further taxonomic studies needed to clarify the taxonomic position of the isolates assigned to it (Varga et al. 2000a, b); exhibits high MICs to some azoles (Alcazar-Fuoli et al. 2007)
Fig. 15. Aspergillus viridinutan. A–B. Colonies 7 d 25 °C. A. CYA. B. MEA. C–J. Conidiophores. J. Conidia. Scale bars = 10 µm.
Neosartorya assulata Hong, Frisvad & Samson [anamorph: A. assulatus Hong, Frisvad & Samson], Antonie van Leeuwenhoek (in press). Fig. 16.

**Type**: KACC 41691, from Tomato field soil, Buyeo, Korea

**Other no. of the type**: IBT 27911

**Morphological characteristics**
Colony diam (7 d): CYA25: (19–)37–41 mm;, MEA25: 47–58 mm; YES25: 28–31 mm; OA25: 36–40; CYA37: 32–68 mm
Colony colour: white
Conidiation: abundant
Reverse colour (CYA): yellowish white to pale yellow
Colony texture: radially sulcate
Conidial head: short columnar
Stipe: 3–7.5 µm wide
Vesicle diam, shape: 10–18 µm, subclavate
Conidium size, shape, surface texture: 2–3 µm, subglobose to ovoid to smooth
Homothallic
Cleistothecia: 120–250 µm, white to yellowish
Ascospores: 5–6 µm, lenticular, with two well-separated equatorial crests and convex surface decorated with several large, round flaps

**Cultures examined**: KACC 41691 = IBT 27911, IBT 27910

**Diagnostic features**: well developed long and round flaps on convex surface of ascospore with two distinct equatorial crests; grow on MEA and CZA much slower than N. pseudofischeri

**Similar species**: N. pseudofischeri

**Distribution**: Korea

**Ecology and habitats**: soil

**Extrolites**: some indole alkaloids and some apolar metabolites

**Pathogenicity**: not reported

Neosartorya aurata (Warcup) Malloch & Cain [anamorph: A. igneus Kozakiewicz], Raper & Fennell 1965. Fig. 17.

**Type**: CBS 466.65, from jungle soil, Berakas, Muama, Brunei

**Other no. of the type**: ATCC 16894; IFO 8783; IMI 075886; IMI 075886ii; MUCL 13579; NRRL 2244; QM 1906; WB 2244; IBT 3027

**Morphological characteristics**
Colony diam (7 d): CYA25: 13–15 mm; MEA25: 30–42 mm; YES25: 17–29 mm; OA25: 31–35 mm; CYA37: 13–16 mm, CREA: weak growth and no acid production
Colony colour (MEA): orange to ochraceus orange
Conidiation: sparse
Reverse colour (CZA): orange to dull brown
Colony texture: velutinous
Conidial head: loosely columnar
Stipe: 60–120 × 2–4 µm
Vesicle diam, shape: 6–9 µm, clavate to flask shaped
Conidium size, shape, surface texture: 3–3.3 µm, globose to subglobose, delicately echinulate
Homothallic
Cleistothecia: 175–500 µm, pale lemon yellow, surrounded by loose wefts of dark golden yellow hyphae
Ascospores: 6–7 × 4.4–5 µm, lenticular, with two prominent equatorial crests and with convex surfaces conspicuously echinulate

**Cultures examined**: CBS 466.65; WB 2391

**Diagnostic features**: yellow to golden pigmentation of hyphae surrounding the cleistothecia

**Similar species**: N. udagawae, A. viridinutans

**Distribution**: Suriname, Ghana, Liberia, Fiji

**Ecology and habitats**: soil, canned passionfruit

**Extrolites**: fumagillin, tryptoquivaline, tryptoquivalone, pseurotin A and viriditoxin (FRR 2269 also produces helvolic acid)

**Pathogenicity**: not reported
Fig. 16. Neosartorya assulata. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 5 µm.
Fig. 17. Neosartorya aurata. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Fig. 18. Neosartorya aureola. A–B. Colonies 14 d 25 °C. A. MEA. B. OA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Neosartorya australensis Samson, Hong & Varga, sp. nov. (Fig. 19) – MycoBank MB492203.

Homothallic; cleistothecia superficialia, luteoalba vel dilute lutea, globosa vel subglobosa, 150–380 µm diam, in hyphis hyalinis vel luteolis laxo obsectis. Asci octospori, globosi vel subglobosi, 12–14 µm diam, evanescentes. Ascosporeae 4.5–7.5 µm diam, crisís angustís, aequatorialis binis, pagina convexa sublaevigata. Mycelium ex hyphis hyalinis, ramosis, septatis, laeviarietis constans. Capitula conidialia curta, columnaria. Conidiophora ex hyphis aeris exorientia, uniseriata, stipitibus 8–14 µm; vesiculae ampulliformes, 12–30 µm diam; phialides 7.5–9 × 2–3 µm, dimidium superior vesiculae obtegentes. Conidia subglobosa vel ellipsoidae, 3.5–5 µm diam. Colonyes in agar in 7 diebus et 25 °C celenter crescentes, 40–45 mm diam, albae, capitulis conidialibus paucis. Colonyae in agar CYA in 7 diebus et 25 °C 30–35 mm diam, cremeoalbae, centro ab hyphis aerialibus laxe obsecto; capitula conidialia pauca; colonia reversa luteoalba vel luteobrunnea.

Holotype of Neosartorya australensis, here designated as CBS 112,555T (dried culture), isolated from garden soil, Adelaide, Australia.

Homothallic; cleistothecia superficial, yellowish white to pale yellow, globose to subglobose, 150–380 µm in diam., surrounded by a loose covering of hyaline to yellowish white hyphae. Asci 8-spored, globose to subglobose 12–14 µm, evanescent at maturity. Ascospores lens-shaped, 4.5–7.5 µm, with two equatorial crests, convex surfaces smooth to microtuberculate. Mycelium composed of hyaline, branched, septate, smooth-walled hyphae. Conidial heads short, columnar. Conidiophores arising from aerial hyphae often curling, uniseriate, stipes 12–30 µm; vesicles flask-shaped, 8–14 µm in diam.; phialides 7.5–9 × 2–3 µm, covering the upper half of vesicle. Conidia subglobose to ellipsoidal, smooth, 2.0–3.2 µm. Colonies on MEA growing rapidly, 40–45 mm in 7 d at 25 °C, white. Conidial heads produced few in number. Colonies on CYA, 30–36 mm in 7 d at 25 °C, creamy white, loosely overgrown by aerial hyphae in center. Conidial heads few in number. Reverse yellowish white to pale yellow.

Etymology: isolated from soil in Australia

Extrolites: wortmannin-like, aszonalenin-like

Distinguishing features: conidiophores often curled

Other no. of the type: IMI 061450; NRRL 2392; IBT 3021; WB 2392; Warcup SA14

Diagnostic features: smooth or microtuberculate 4.5–7.5 µm ascospores

Similar species: N. glabra

Distribution: South Korea, Australia

Ecology and habitats: soil, strawberry

Extrolites: aszonalenins

Pathogenicity: not reported in humans (although isolated from the air sacks of an ostrich: Katz et al. 2005)

Neosartorya denticulata Samson, Hong & Frisvad [anamorph: A. denticulatus Samson, Hong & Frisvad], Antonie van Leeuwenhoek (in press). Fig. 21.

Type: CBS 652.73, from Soil under Elaeis guineensis, Suriname

Other no. of the type: KACC 41183

Morphological characteristics

Colony diam (7 d): CYA25: 22–24 mm; MEA25: 35–40 mm; CYA37: 35–38 mm; CREA: poor growth, no acid production

Colony colour: white

Conidiation: only on the marginal area

Reverse colour (CYA): yellowish white to pale yellow

Colony texture: loosely overgrown by aerial hyphae in the centre, sulcate in marginal areas

Conidial head: short columnar

Stipe: 3–4.5 µm wide

Vesicle diam, shape: 7–12 µm, spathulate

Conidium size, shape, surface texture: 2–3 µm, subglobose to broadly elliptical, smooth

Homothallic

Cleistothecia: 140–230 µm, yellowish white to pale yellow

Ascospores: 4–5 µm, denticulate with a prominent equatorial furrow

Cultures examined: CBS 652.73

Diagnostic features: denticulate ascospore surface and lacking equatorial crests make this a distinctive species

Similar species: N. fennelliae, N. ferenzii
Fig. 19. Neosartorya australiensis. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 μm, except D = 30 μm, E = 15 μm, I = 1 μm.
Fig. 20. Neosartorya coreana. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Fig. 21. Neosartorya denticulata. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 5 µm.
Distribution: Netherlands, Suriname

Ecology and habitats: soil, sycamore

Extrolites: gliotoxin, viriditoxin

Pathogenicity: not reported

Neosartorya fennelliae Kwon-Chung & Kim [anamorph: A. fennelliae Kwon-Chung & Kim], Mycologia 66: 628. 1974. Fig. 22.

Type: CBS 598.74 & CBS 599.74, from eye ball of Oryctolagus cuniculus, U.S.A.

Other no. of the type: ATCC 24325 & ATCC 24326, NRRL 5534 & NRRL 5535

Morphological characteristics
Colony diam (7 d): CYA25: 25–30 mm; MEA25: 44–48 mm; YES25: 30–34 mm; OA25: 34–38 mm; CYA37: 50–58 mm; CREA: poor growth and no acid production

Colony colour: grey

Conidiation: abundant

Reverse colour (CZA): white

Colony texture: velutinous

Conidial head: short columnar

Stipe: 150–250 × 4–6 µm

Vesicle diam, shape: 10–17 µm, flask-shaped

Conidium size, shape, surface texture: 2.2–2.5 (–2.8) µm, globose to subglobose to ellipsoid, smooth or finely roughened

Heterothallic

Cleistothecia: 150–450 µm, white

Ascospores: 5.5–7.7 × 3.2–5 µm, with two equatorial crests, convex surfaces delicately roughened

 Cultures examined: CBS 598.74, CBS 599.74

Diagnostic features: heterothallic

Similar species: N. denticulata, N. ferenczii

Distribution: U.S.A., Japan, South Korea

Ecology and habitats: soil, mite sludge, rabbit

Extrolites: asperfuran, aszonalenin, fumigaclavine, viridicatumtoxin, gliotoxin-like, fumigatins and aszonalenin-like

Type: CBS 121594, from soil, Australia

Other no. of the type: IBT 27813; YM 181; QM 1983; Thom 4651.2, WB 181; IBT 3018

Diagnostic features: ascospore ornamentation similar to that of N. fennelliae, but with equatorial crests much narrower, and markedly different from those of N. denticulata

Similar species: N. fennelliae, N. denticulata

Distribution: Australia

Ecology and habitats: soil

Extrolites: asperfuran, aszonalenin, fumigaclavine, viridicatumtoxin, gliotoxin-like, fumigatins, and aszonalenin-like

Pathogenicity: not reported

Neosartorya ferenczii (Wehmer) Malloch & Cain [anamorph: A. fischeri Kozakiewicz], Can. J. Bot. 50: 2621. 1973. Fig. 24.

Type: CBS 544.65, from canned apples, Wehmer

Other no. of the type: ATCC 1020; DSM 3700; IMI 211391; NRRL 181; QM 1983; Thom 4651.2, WB 181; IBT 3018

Morphological characteristics
Colony diam (7 d): CYA25: 25–30 mm; MEA25: 44–48 mm; YES25: 30–34 mm; OA25: 34–38 mm; CYA37: 50–58 mm; CREA: poor growth and no acid production

Colony colour (CZA): white to pale yellow to buff

Conidiation: sparse

Reverse colour (CZA): colourless to flesh coloured

Note: no growth at 47 °C

Neosartorya fischeri (Vuill., Compt. rendu Acad. Sci. Paris 184: 136. 1927.) = Sartorya fumigata Vuill., Compt. rendu Acad. Sci. Paris 184: 136. 1927.

Type: CBS 544.65, from canned apples, Wehmer

Other no. of the type: CBS 121594

Morphological characteristics
Colony diam (7 d): CYA25: 45–68 mm; MEA25: 66–80 mm; YES25: 70–80 mm; OA25: 58–80 mm; CYA37: 65–84 mm; CREA: poor growth and no acid production

Colony colour (CZA): white to pale yellow to buff

Conidiation: sparse

Reverse colour (CZA): colourless to flesh coloured
Fig. 22. Neosartorya fennelliae. A–B. Colonies 14 d 25 °C. A. MEA. B–C. Crossing of mating types on MEA. D–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Fig. 23. *Neosartorya fennecii*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Ascii and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Fig. 24. *Neosartorya fischeri*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C. Macroscopic view of the columnar conidial heads. D–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Colony texture: velutinous
Conidial head: columnar
Stipe: 300–500 × 4–7 µm
Vesicle diam, shape: 12–18 µm, flask shaped
Conidium size, shape, surface texture: 2–2.5 µm, globose to subglobose, microtuberculate
Homothallic
Cleistothecia: up to 400 µm, light cream, borne singly or in small clusters within a loose hyphal envelope
Ascospores: 7–8 × 3–4 µm, convex surfaces bearing anastomosing ridges (reticulate)

Cultures examined: CBS 544.65; WB 4075; CBS 317.89; CBS 584.90; CBS 118441; NRRL 181; NRRL 4075; NRRL 4161; NRRL 4585

Diagnostic features: reticulate ascospore ornamentation

Similar species: N. tatenoi

Distribution: worldwide

Ecology and habitats: Soil, (milled) rice, cotton, potatoes, groundnuts, leather, paper products, canned products, human

Extrolites: terrein, fumitremorgins A & C, tryptoquivaline A, trypacidin, TR-2, verruculogen, sarasin, aszonalenins, fischerin, neosartorin, fisca "lins, helvolic acid

Pathogenicity: pathogenic to animals and humans (Coriglione et al. 1990; Lonial et al. 1997; Mellado et al. 2006; Chim et al. 1998; Gori et al. 1998)

Neosartorya galapagensis Frisvad, Hong & Samson [anamorph: A. galapagensis Frisvad, Hong & Samson], Antonie van Leeuwenhoek (in press). Fig. 25.

Type: CBS 117522, from soil, Galapagos Islands, Ecuador

Other no. of the type: KACC 41935 = IBT 16756

Morphological characteristics
Colonial diam (7 d): CYA25: 25–40 mm; MEA25: 26–35 mm; YES25: 39–44 mm; OA25: 34–41 mm; CYA37: 44–65 mm; CREA: poor growth and no acid production
Colonial colour: white
Conidiation: sparse
Reverse colour (CZA): golden yellow
Colony texture: strongly funiculose
Conidial head: columnar
Stipe: 2–4 µm wide
Vesicle diam, shape: 4–11 µm, (sub)clavate
Conidium size, shape, surface texture: 2.3–3 µm, globose to subglobose, smooth
Homothallic
Cleistothecia: 90–220 µm, yellowish white, surrounded by a loose covering of aerial hyphae
Ascospores: 5 µm, with two distinct equatorial crests 1–2 µm wide, convex surface of ascospores microtuberculate

Cultures examined: CBS 117522 = IBT 16756; CBS 117521 = IBT 16756

Diagnostic features: colonies funiculose, the Aspergillus anamorph arises from bundles of aerial hyphae, ascospores with two wide conspicuous equatorial crests and with microtuberculate convex surface

Similar species: N. glabra, N. australensis

Distribution: Galapagos Islands (Ecuador)

Ecology and habitats: soil

Extrolites: gregatins

Pathogenicity: not reported

Neosartorya glabra (Fennell & Raper) Kozakiewicz [anamorph: A. neoglaber Kozakiewicz], Mycol. Pap. 161: 56. 1989. Fig. 26.

Type: CBS 111.55, from rubber scab of an old tire, Iowa, U.S.A.

Other no. of the type: ATCC 16909; IFO 8789; IMI 061447; IMI 061447ii; NRRL 2163; QM 1903; WB 2163

Morphological characteristics
Colonial diam (7 d): CYA25: 24–43 mm; MEA25: 49–66 mm; YES25: 45–54 mm; OA25: 55–76 mm; CYA37: 30–80 mm; CREA: poor growth and no acid production
Colonial colour (CZA): white to pale yellow to buff
Conidiation: sparse
Reverse colour (CZA): colourless to light pink
Colony texture: velutinous
Conidial head: columnar
Stipe: 300–500 × 4–7 µm
Vesicle diam, shape: 10–18 µm, flask shaped
Conidium size, shape, surface texture: 2.5–3.5 µm, globose to subglobose, microtuberculate
Homothallic
Cleistothecia: 100–500 µm, yellowish white
Ascospores: 6.5–7.5 × 4.5–5 µm, lenticular, with two equatorial crests of 1–1.5 µm, convex surfaces finely roughened

Cultures examined: CBS 111.55; IMI 144207; IMI 102073; CBS 165.63

Diagnostic features: has smaller and whiter cleistothecia and relatively straight equatorial crests and smoother walled convex surfaces compared to N. laciniosa, N. coreana and N. spinosa; N. glabra grows somewhat slower than the other species and grows well at comparatively low temperatures; can be distinguished from N. papuensis and N. australensis using sequence data or extrolite profiles

Similar species: N. papuensis, N. australensis

Distribution: U.S.A., Morocco, Denmark, Australia, Netherlands, South Korea

Ecology and habitats: soil, foods, indoor

Extrolites: asperpentyn, avenaciolide, wortmannin-like compound

Pathogenicity: not reported
Fig. 25. Neosartorya galapagensis. A–B. Colonies 14 d 25 °C. A. CYA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 5 µm.
Fig. 26. Neosartorya glabra. A–B. Colonies 14 d 25 °C. A. OA, B. MEA, C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Fig. 27. *Neosartorya hiratsukae*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
**Neosartorya hiratsukae** Udagawa, Tsubouchi & Horie [anamorph: *A. hiratsukae* Udagawa, Tsubouchi & Horie], Trans. Mycol. Soc. Japan 32: 23. 1991. Fig. 27.

**Type**: NHL 3008, from pasteurised aloe juice, Tokyo, Japan

**Other no. of the type**: CBS 294.93; NRRL 20819

**Morphological characteristics**
- Colony diam (7 d): CZA25: 14–15 mm; CYA25: 12–14 mm; MEA25: 26–39 mm; YES25: 42–45 mm; OA25: 42–45 mm; CYA37: 27–30 mm; CREA: rather poor growth and no acid production
- Colony colour: greyish green
- Conidiation: moderate
- Reverse colour (CZA): light brown
- Colony texture: velutinous
- Conidial head: short columnar
- Stipe: 120–380 x 5–7 µm
- Vesicle diam, shape: 15–24 µm, flask-shaped
- Conidium size, shape, surface texture: 2–2.5 µm, globose to subglobose, smooth or delicately roughened
- Homothallic
- Cleistothecia: 130–220 µm, light cream coloured
- Ascospores: 4.5–5 µm, broadly lenticular, with two closely appressed equatorial crests, convex surfaces finely reticulate

**Cultures examined**: CBS 294.93; IFM 50770 = IBT 27913

**Diagnostic features**: restricted growth on CZA, small cleistothecia, finely reticulate ascospores

**Similar species**: *N. fischeri*, *N. tatenoi*

**Distribution**: Japan, Brazil, South Korea

**Ecology and habitats**: soil, fruit juice, indoor air, human

**Extralites**: avenaciolide

**Pathogenicity**: pathogenic to humans (Guarro et al. 2002; Mellado et al. 2006; Alcazar-Fuoli et al. 2007)

**Note**: no growth above 48 °C; some isolates carry dsRNA mycoviruses which are efficiently transmitted both through ascospores and conidia to the progeny (Varga et al. 1998)

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**Neosartorya laciniosa** Hong, Frisvad & Samson [anamorph: *A. laciniosus* Hong, Frisvad & Samson], Int. J. Syst. Evol. Microbiol. 56: 477. 2006. Fig. 28.

**Type**: CBS 117721, from tomato field soil, Buyeo, Korea

**Other no. of the type**: NRRL 35589 = KACC 41657

**Morphological characteristics**
- Colony diam (7 d): CYA25: 38–58 mm; MEA25: 53–67 mm; YES25: 60–78 mm; OA25: 52–59 mm; CYA37: 41–80 mm; CREA: poor growth and no acid production
- Colony colour: white to pale yellow
- Conidiation: sparse
- Reverse colour (CYA): greyish yellow to olivaceous buff
- Colony texture: floccose
- Conidial head: loosely columnar
- Stipe: 20–160 x 2.5–4 µm
- Vesicle diam, shape: 4–8 µm, flask-shaped to irregular
- Conidium size, shape, surface texture: 2.5–4 µm, globose to subglobose, smooth
- Homothallic
- Cleistothecia: 100–300 µm, cream coloured
- Ascospores: 4–5 µm, with a shallow furrow but without distinct equatorial crests, ornamented on surfaces by several linear ridges presenting ribbed or somewhat reticulate pattern

**Cultures examined**: CBS 117721; IBT 6660; KACC 41648; CBS 117719 = KACC 41652; KACC 41644

**Diagnostic features**: cleistothecia surrounded by a loose covering of hyaline to yellowish white, 2–4 µm wide hyphae; microtuberculate ascospores with two bent crests and two distinct equatorial rings of small projections

**Similar species**: *N. spinosa*, *N. coreana*

**Distribution**: South Korea, U.S.A., Pakistan, Netherlands, Suriname, Dominican Republic, Kenya

**Ecology and habitats**: soil

**Extralites**: aszonalenins, tryptoquivaline, tryptoquivalone

**Pathogenicity**: not reported

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**Neosartorya multiplicata** Yaguchi, Someya & Udagawa [anamorph: *A. multiplicatus* Yaguchi, Someya & Udagawa], Mycoscience 35: 309. 1994. Fig. 29.

**Type**: PF 1154, from soil, Taiwan

**Other no. of the type**: CBS 646.95, IBT 17517

**Morphological characteristics**
- Colony diam (7 d): CYA25: 24–36 mm; MEA25: 35–50 mm; YES25: 38–42 mm; OA28–43 mm; CYA37: 41–80 mm, CREA: poor growth and no acid production
- Colony colour: white
- Conidiation: sparse
- Reverse colour (CYA): greyish orange to yellowish orange
- Colony texture: sulcate, granular
- Conidial head: loosely columnar
- Stipe: 20–160 x 2.5–4 µm
- Vesicle diam, shape: 4–8 µm, flask-shaped to irregular
- Conidium size, shape, surface texture: 2.5–4 µm, globose to subglobose, smooth
- Homothallic
- Cleistothecia: 100–300 µm, cream coloured
- Ascospores: 4–5 µm, lenticular, with two closely appressed equatorial crests, convex surfaces finely reticulate

**Cultures examined**: CBS 646.95; IFM 50770 = IBT 27913

**Diagnostic features**: can be distinguished from other species of *Neosartorya* by its almost globose ascospores, which have ribbed ornamentation with several linear ridges presenting ribbed or somewhat reticulate pattern

**Similar species**: none

**Distribution**: Taiwan

**Ecology and habitats**: soil

**Extralites**: helvolic acid

**Pathogenicity**: not reported
Fig. 28. Neosartorya laciniosa. A–B. Colonies 14 d 25 °C. A. MAA. B. CYA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Fig. 29. Neosartorya multiplicata. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C. Macroscopic view of the columnar conidial heads D–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Fig. 30. Neosartorya papuensis. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
**Neosartorya papuensis** Samson, Hong & Varga, sp. nov. (Fig. 30) – MycoBank MB505571.

Homothallic; cleistothecia superficial, yellowish white to pale yellow, globose to subglobose, 200–350 µm in diam., surrounded by a loose covering of hyaline to yellowish white hyphae. Asci 8-spored, globose to subglobose 14–20 µm, evanescent at maturity. Ascospores 5.5–7.5 µm, with two equatorial crests, convex surface smooth microtuberculate. Mycelium composed of hyaline, branched, septate, smooth-walled hyphae. Conidial heads short, columnar. Conidiophores arising from aerial hyphae, uniseriate, stipes 100–150 × 4–5 µm; vesicles flask-shaped, 10–14 µm in diam.; phialides 7.5–9 × 2–3 µm, covering the upper half of vesicle. Conidia globose to subglobose, 2–3 µm. Colonies on MEA growing rapidly, 35–40 mm in diam., producing sectors, creamy white, loosely overgrown by aerial hyphae in center. Conidial heads few in number. Reverse yellowish white to pale yellow (12A23) (Kornerup and Wanscher 1978).

Holotype of *Neosartorya papuensis*, here designated as CBS 841.96' (dried culture), isolated from *Podocarpus* (Podocarpaceae), bark, Myola, Owen Stanley Range, Northern Province, Papua New Guinea.

Homothallic, cleistothecia superficial, yellowish white to pale yellow, globose to subglobose, 200–350 µm in diam., surrounded by a loose covering of hyaline to yellowish white hyphae. Asci 8-spored, globose to subglobose 14–20 µm, evanescent at maturity. Ascospores 5.5–7.5 µm, with two equatorial crests, convex surface smooth microtuberculate. Mycelium composed of hyaline, branched, septate, smooth-walled hyphae. Conidial heads short, columnar. Conidiophores arising from aerial hyphae, uniseriate, stipes 100–150 × 4–5 µm; vesicles flask-shaped, 10–14 µm in diam.; phialides 7.5–9 × 2–3 µm, covering the upper half of vesicle. Conidia globose to subglobose, smooth, 2–3 µm. Colonies on MEA growing rapidly, 35–40 mm in 7 d at 25 °C, producing sectors, creamy white, loosely overgrown by aerial hyphae in center. Conidial heads few in number. Reverse yellowish white to pale yellow (12A23) (Komerup and Wanscher 1978).

**Etymology:** isolated in Papua New Guinea.

**Extrrolites:** wortmannin-like

**Distinguishing features:** smooth microtuberculate 5.5–7.5 µm, ascospores

**Other no. of the type:** IBT 27801

**Cultures examined:** CBS 841.96

**Similar species:** *N. galapagensis*, *N. glabra*, *N. australensis*

**Distribution:** Papua New Guinea

**Pathogenicity:** not reported

**Neosartorya pseudofischeri** Peterson [anamorph: *A. thermomutatus* (Paden) Peterson], Mycol. Res. 86: 547. 1992. Fig. 31.

**Type:** NRRL 20748, from human vertebrae, Atlanta, Georgia, U.S.A.

**Other no. of the type:** CBS 208.92

**Holotype:** 404.67, moldy cardboard, Victoria, British Columbia, Canada

**Morphological characteristics**

- Colony diam (7 d): CYA25: 60–70 mm; MEA25: 90 mm in 7 d
- Colony colour: white to pale creamish
- Conidiation: sparse
- Reverse colour (CZA): clear or faintly yellowish
- Colony texture: velutinous
- Conidial head: loosely columnar
- Stipe: 200–300 × 4–7 µm
- Vesicle diam, shape, surface texture: 3–4 µm, globose to subglobose, smooth

**Homothallic**

- Cleistothecia: 150–300 µm, white
- Ascospores: 4.5–6 µm, globose to subglobose, with two equatorial crests of 1 µm wide, convex surfaces with raised flaps resembling triangular projections

**Cultures examined:** CBS 208.92, CBS 404.67

**Diagnostic features:** distinctly ornamented ascospores

**Similar species:**

**Ecology and habitats:** soil, indoor, human

**Extrrolites:** asperfuran, cytochalasin-like compound, fiscalin-like compound, pyripyropens, gliotoxin

**Pathogenicity:** pathogenic to humans (Padhye et al. 1994; Matsumoto et al. 2002; Jarv et al. 2004; Balajee et al. 2005a; Alcazar-Fuoli et al. 2007; Lau et al. 2007) and animals (Barrs et al. 2007)

**Neosartorya quadricingens** (J.L. Yüll) Malloch & Cain [anamorph: *A. quadricingens* Kozakiewicz], Can. J. Bot. 50: 2621. 1973. Fig. 32.

**Type:** CBS 135.52, from cardboard, York, U.K.

**Other no. of the type:** ATCC 16897; IMI 048583; IMI 048583ii; NRRL 2154; QM 6874; WB 2154

**Morphological characteristics**

- Colony diam (7 d): CYA25: 26–42 mm; MEA25: 52–59 mm; YES25: 36–59 mm; OA25: 47–55 mm; CYA37: 50–58 mm; CREA: poor growth and no acid production
- Colony colour (CZA): white to light tan
- Conidiation: sparse
- Reverse colour (CZA): colourless to flesh coloured
- Colony texture: floccose
- Conidial head: loosely columnar
- Stipe: 400–500 × 2–7 µm
- Vesicle diam, shape, flask shaped
- Conidium size, shape, surface texture: 2–3 µm, elliptical to globose, microtuberculate

**Homothallic**

- Cleistothecia: up to 300 µm, buff to light tan
Fig. 31. Neosartorya pseudofischeri. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Fig. 32. Neosartorya quadricincta. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Ascospores: 4–5 µm, with two prominent equatorial crests, each duplicated by a somewhat less prominent band, reticulate

Cultures examined: CBS 135.52; WB 2221; WB 4175; CBS 100942

Diagnostic features: presence of 4 equatorial crests on ascospores, reticulate ascospore ornamentation

Similar species: -

Distribution: Suriname, South Korea, U.K., Netherlands, Australia

Ecology and habitats: Soil, pectin, cardboard, fruit juice, mango pulp

Extrolites: quinolactacin, aszonalenins

Pathogenicity: not reported

Note: some isolates carry dsRNA mycoviruses (Varga et al. 1998)

Neosartorya spathulata Takada & Udagawa [anamorph: A. spathulatus Takada & Udagawa], Mycotaxon 24: 395. 1985. Fig. 33.

Type: CBS 408.89 & CBS 409.89, from cultivated soil under Alocasia macrorrhiza, Taiwan

Other no. of the type: IMI 308593 & IMI 308593; NHL 2948, NHL 2949; NRRL 20549 & NRRL 20550

Morphological characteristics
Colony diam (7 d): CZA25: 33–38 mm, MEA25: 80 mm; OA25: 40–46 mm
Colony colour: greyish green
Conidiation: abundant
Reverse colour (CZA): uncoloured
Colony texture: velutinous
Conidial head: loosely columnar
Stipe: 500–1500 × 11–18(–25) µm and 60–250 × 4–10 µm
Vesicle diam, shape: 25–52 µm and 8–15 µm, flask-shaped
Conidium size, shape, surface texture: 3–5.5 × 2–4.5 µm, ellipsoidal, smooth
Heterothallic
Cleistothecia: 100–260 µm, pale yellow to light yellow
Ascospores: 3.5–4 µm, lenticular, with two equatorial crests, convex surfaces nearly smooth

Cultures examined: CBS 408.89 & CBS 409.89

Diagnostic features: have echinulate ascospores with spines ranging from <0.5 µm up to 7 µm long, or with verruculose and small triangular, sometimes circularly arranged, projections

Similar species: N. coreana, N. laciniosa

Distribution: Nicaragua, Kenya, Denmark, Dominican Republic, U.S.A., Belgium, Sudasn, Japan, India, Pakistan, South Korea

Ecology and habitats: Soil, fruit juice, human

Extrolites: aszonalenins, 2-pyrovoylaminobenzamide, pseurotin

Pathogenicity: pathogenic to humans (Summerbell et al. 1992; Mellado et al. 2006; Gerber et al. 1973)

Neosartorya spinosa (Raper & Fennell) Kozakiewicz [anamorph: A. spinosus Kozakiewicz], Mycol. Pap. 161: 58. 1989. Fig. 34.

Type: CBS 483.65, from soil, Nicaragua

Other no. of the type: ATCC 16898; IFO 8782; IMI 211390; NRRL 5034; WB 5034; IBT 3022

Morphological characteristics
Colony diam (7 d): CYA25: 41–70 mm; MEA25: 55–75 mm; YES25: 55–80 mm; OA25: 56–64 mm; CYA37: 67–85 mm; CREA: poor growth and no acid production
Colony colour (CZA): white to pale yellow to buff
Conidiation: sparse
Reverse colour (CZA): colourless to light pink
Colony texture: velutinous
Conidial head: columnar
Stipe: 300–500 × 4–7 µm
Vesicle diam, shape: 12–18 µm, flask shaped
Conidium size, shape, surface texture: 2–2.5 µm, globose to subglobose, microtuberculate
Homothallic
Cleistothecia: 200–300 µm, cartridge buff
Ascospores: 4.5 µm, with two widely separated equatorial crests, with convex surfaces bearing spinelike projections

Cultures examined: CBS 483.65

Diagnostic features: have echinulate ascospores with spines ranging from <0.5 µm up to 7 µm long, or with verruculose and small triangular, sometimes circularly arranged, projections

Similar species: N. coreana, N. laciniosa

Distribution: Nicaragua, Kenya, Denmark, Dominican Republic, U.S.A., Belgium, Sudasn, Japan, India, Pakistan, South Korea

Ecology and habitats: Soil, fruit juice, human

Extrolites: aszonalenins, 2-pyrovoylaminobenzamide, pseurotin

Pathogenicity: pathogenic to humans (Summerbell et al. 1992; Mellado et al. 2006; Gerber et al. 1973)

Neosartorya stramenia (R.O. Novak & Raper) Malloch & Cain [anamorph: A. palaeaceus Samson & Gams], Can. J. Bot. 50: 2622. 1972. Fig. 35.

Type: CBS 498.65, soil from maple-ash-elm forest, Wisconsin, U.S.A.

Other no. of the type: ATCC 16895; IFO 9611; IMI 172293; WB 4652

Morphological characteristics
Colony diam (7 d): CYA25: 10–40; MEA25: 40–59 mm; YES25: 58–62 mm; OA: 56–60 mm; CYA37: 45–49 mm; CREA: poor growth and no acid production
Fig. 33. Neosartorya spathulata. A–B. Colonies 14 d 25 °C. A. MEA. B–C. Crossing of mating types on MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Fig. 34. Neosartorya spinosa. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Colony colour (CZA): mustard-yellow
Conidiation: sparse
Reverse colour (CZA): yellow-orange
Colony texture: granulose
Conidial head: loosely columnar
Stipe: 80–140 × 3.5–5.5 µm, heavy walled, septate, coloured in terminal areas
Vesicle diam, shape: 10–12 µm, flask shaped to globose
Conidium size, shape, surface texture: 2.5–3 µm, globose, microverrucose
Homothallic
Cleistothecia: 50–175 µm, cartridge buff
Ascospores: 4.5–5.5 µm, with two widely separated flexuous equatorial crests, convex surfaces finely echinulate
Cultures examined: CBS 498.65; IFO 31358
Diagnostic features: faster growth rate and pronounced echinulate ascospore ornamentation distinguishes this species from N. aurata
Similar species: N. aurata
Distribution: U.S.A., Argentina
Ecology and habitats: Soil, salt grass (Distichlis scoparia)
Extrolites: quinolactacin, avenaciolide
Pathogenicity: not reported

**Neosartorya tatenoi** Horie, Miyaji, Yokoyama, Udagawa & Campos-Takagi [anamorph: A. tatenoi Y. Horie, M. Miyaji, K. Yokoy., Udagawa & Campos-Takagi], Trans. Mycol. Soc. Japan 33: 395. 1992. Fig. 36.

Type: CBM FA 0022, from soil, Brazil
Other no. of the type: CBS 407.93; IBT 21589
Morphological characteristics
Colony diam (7 d): CYA25: 35–39 mm; MEA25: 31–39 mm; YES25: 57–74 mm; OA25: 50–55 mm; CYA37: 72–78 mm; CREA: poor growth and no acid production
Colony colour: pale yellow to yellowish white
Conidiation: sparse
Reverse colour (CZA): orange white to pale orange
Colony texture: velutinous to floccose
Conidial head: short columnar
Stipe: 270 × 4–7.5 µm
Vesicle diam, shape: 10–20 µm, hemispherical to flask-shaped
Conidium size, shape, surface texture: 2–3(–3.5) µm, globose to ovoid, smooth
Homothallic
Cleistothecia: 140–360 × 140–310 µm, hyaline to pale yellowish brown
Ascospores: 5–5.5 × 4–5 µm, broadly lenticular, with two equatorial or often irregular crests, convex surfaces tuberculate
Cultures examined: CBS 407.93; NRRL 4584
Diagnostic features: distinct narrowly reticulate ascospore ornamentation
Similar species: N. fischeri, N. multiplicata

**Neosartorya udagawae** Horie, Miyaji & Nishim. [anamorph: A. udagawae Horie, Miyaji & Nishim.], Mycoscience 36: 199. 1995. Fig. 37.

Type: CBM FA-0703 & CBM FA-0702, from soil, Brazil
Other no. of the type: CBS 114217 & CBS 114218
Morphological characteristics
Colony diam (7 d): CYA25: 33–36 mm; MEA25: 63–68 mm; YES25: 64–68 mm; OA25: 51–55 mm; CYA37: 61–65mm; CREA: poor growth and no acid production
Colony colour (CZA): dull green
Conidiation: abundant
Reverse colour (CZA): light orange to greyish orange
Colony texture: velutinous
Conidial head: columnar
Stipe: up to 530 × 4–6 µm
Vesicle diam, shape: 12–15 µm, hemispherical to flask shaped
Conidium size, shape, surface texture: 2.6–3.2 × 2.4–2.6 µm, subglobose to broadly ellipsoidal, smooth
Heterothallic
Cleistothecia: 310–620 x 280–530 µm, yellowish white to light yellow, surrounded by a loose covering of hyaline to pale yellowish brown hyphae
Ascospores: 5–5.5 × 4–5 µm, broadly lenticular, with two equatorial or often irregular crests, convex surfaces tuberculate
Cultures examined: CBS 114217, CBS 114218
Diagnostic features: heterothallic species, with characteristic tuberculate ascospore ornamentation
Similar species: N. aureola, A. viridinutans
Distribution: Brazil, U.S.A., Spain, Japan
Ecology and habitats: Soil, human
Extrolites: fumigatin, fumagillin, tryptoquivaline, tryptoquivalone
Pathogenicity: pathogenic to humans (Balajee et al. 2006; Moragues et al. 2006)
Fig. 35. *Neosartorya stramenia*. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Fig. 36. Neosartorya tatenoi. A–B. Colonies 14 d 25 °C. A. MEA. B. OA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Fig. 37. Neosartorya udagawae. A–B. Colonies 14 d 25 °C. A. MEA. B. Crossing of mating types on MEA. C–E. Ascomata. F–G. Asci and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Fig. 38. Neosartorya warcupii. A–B. Colonies 14 d 25 °C. A. OA. B. MEA. C–E. Ascomata. F–G. Ascii and ascospores. H. Ascospores. I. SEM of ascospores. J–L. Conidiophores. M. Conidia. Scale bars = 10 µm, except D = 30 µm, E = 15 µm, I = 1 µm.
Neosartorya warcupii  

**Peterson, Varga & Samson, sp. nov.** (Fig. 38) – MycoBank MB505572.

Homothallic; cleistothecia superficialia, alba vel dilute lutea, globosa vel subglobosa, 200–350 µm diam, in hypha hyalinis vel luteoalbis laxe obtectis. Ascii octospori, globosi vel subglobosi, 4.5–7 µm diam, evanescentes. Ascosporae 5.5–7 µm diam, criatalis angustis, aequatoriis binis, pagina convexa sublaevigata. Mycelium ex hyphis hyalinis, ramosis, septatis, laeviparietinis constans. Capitula conidialia curta, columnarria. Conidiorapha ex hyphis aeris exorientai, uniseriata, stipitata, 100–150 × 4–5 µm; vesiculae amphulliformes, 10–25 µm diam; phiilaides 7.5–9 x 2–3 µm, dimumidum supremum vesiculae obtegentes. Conidio subglobosa vel ellipsoides, laevia, 1.8–1.5 µm diam. Colonieae in agaro MEA in 7 diebus et 25 °C colorante crescentes, 25–40 mm diam, albae, capitulis conidialibus paucis. Colonieae 7.5–9 x 2–3 µm, dimidium supernum vesiculae obtegentes. Conidia subglobose, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Asci subgloosi, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Ascii octospori, globosi vel subglobosi, 4.5–7 µm diam, evanescentes. Ascosporae 5.5–7 µm diam, criatalis angustis, aequatoriis binis, pagina convexa sublaevigata. Mycelium ex hyphis hyalinis, ramosis, septatis, laeviparietinis constans. Capitula conidialia curta, columnarria. Conidiorapha ex hyphis aeris exorientai, uniseriata, stipitata, 100–150 × 4–5 µm; vesiculae amphulliformes, 10–25 µm diam; phiilaides 7.5–9 x 2–3 µm, dimumidum supremum vesiculae obtegentes. Conidio subglobosa vel ellipsoides, laevia, 1.8–1.5 µm diam. Colonieae in agaro MEA in 7 diebus et 25 °C colorante crescentes, 25–40 mm diam, albae, capitulis conidialibus paucis. Colonieae 7.5–9 x 2–3 µm, dimidium supernum vesiculae obtegentes. Conidia subglobose, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Asci subgloosi, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Ascii octospori, globosi vel subglobosi, 4.5–7 µm diam, evanescentes. Ascosporae 5.5–7 µm diam, criatalis angustis, aequatoriis binis, pagina convexa sublaevigata. Mycelium ex hyphis hyalinis, ramosis, septatis, laeviparietinis constans. Capitula conidialia curta, columnarria. Conidiorapha ex hyphis aeris exorientai, uniseriata, stipitata, 100–150 × 4–5 µm; vesiculae amphulliformes, 10–25 µm diam; phiilaides 7.5–9 x 2–3 µm, dimumidum supremum vesiculae obtegentes. Conidio subglobosa vel ellipsoides, laevia, 1.8–1.5 µm diam. Colonieae in agaro MEA in 7 diebus et 25 °C colorante crescentes, 25–40 mm diam, albae, capitulis conidialibus paucis. Colonieae 7.5–9 x 2–3 µm, dimidium supernum vesiculae obtegentes. Conidia subglobose, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Asci subgloosi, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Ascii octospori, globosi vel subglobosi, 4.5–7 µm diam, evanescentes. Ascosporae 5.5–7 µm diam, criatalis angustis, aequatoriis binis, pagina convexa sublaevigata. Mycelium ex hyphis hyalinis, ramosis, septatis, laeviparietinis constans. Capitula conidialia curta, columnarria. Conidiorapha ex hyphis aeris exorientai, uniseriata, stipitata, 100–150 × 4–5 µm; vesiculae amphulliformes, 10–25 µm diam; phiilaides 7.5–9 x 2–3 µm, dimumidum supremum vesiculae obtegentes. Conidio subglobosa vel ellipsoides, laevia, 1.8–1.5 µm diam. Colonieae in agaro MEA in 7 diebus et 25 °C colorante crescentes, 25–40 mm diam, albae, capitulis conidialibus paucis. Colonieae 7.5–9 x 2–3 µm, dimidium supernum vesiculae obtegentes. Conidia subglobose, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Asci subgloosi, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Ascii octospori, globosi vel subglobosi, 4.5–7 µm diam, evanescentes. Ascosporae 5.5–7 µm diam, criatalis angustis, aequatoriis binis, pagina convexa sublaevigata. Mycelium ex hyphis hyalinis, ramosis, septatis, laeviparietinis constans. Capitula conidialia curta, columnarria. Conidiorapha ex hyphis aeris exorientai, uniseriata, stipitata, 100–150 × 4–5 µm; vesiculae amphulliformes, 10–25 µm diam; phiilaides 7.5–9 x 2–3 µm, dimumidum supremum vesiculae obtegentes. Conidio subglobosa vel ellipsoides, laevia, 1.8–1.5 µm diam. Colonieae in agaro MEA in 7 diebus et 25 °C colorante crescentes, 25–40 mm diam, albae, capitulis conidialibus paucis. Colonieae 7.5–9 x 2–3 µm, dimidium supernum vesiculae obtegentes. Conidia subglobose, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Asci subgloosi, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Ascii octospori, globosi vel subglobosi, 4.5–7 µm diam, evanescentes. Ascosporae 5.5–7 µm diam, criatalis angustis, aequatoriis binis, pagina convexa sublaevigata. Mycelium ex hyphis hyalinis, ramosis, septatis, laeviparietinis constans. Capitula conidialia curta, columnarria. Conidiorapha ex hyphis aeris exorientai, uniseriata, stipitata, 100–150 × 4–5 µm; vesiculae amphulliformes, 10–25 µm diam; phiilaides 7.5–9 x 2–3 µm, dimumidum supremum vesiculae obtegentes. Conidio subglobosa vel ellipsoides, laevia, 1.8–1.5 µm diam. Colonieae in agaro MEA in 7 diebus et 25 °C colorante crescentes, 25–40 mm diam, albae, capitulis conidialibus paucis. Colonieae 7.5–9 x 2–3 µm, dimidium supernum vesiculae obtegentes. Conidia subglobose, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Asci subgloosi, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis. Ascii octospori, globosi vel subglobosi, 4.5–7 µm diam, evanescentes. Ascosporae 5.5–7 µm diam, criatalis angustis, aequatoriis binis, pagina convexa sublaevigata. Mycelium ex hyphis hyalinis, ramosis, septatis, laeviparietinis constans. Capitula conidialia curta, columnarria. Conidiorapha ex hyphis aeris exorientai, uniseriata, stipitata, 100–150 × 4–5 µm; vesiculae amphulliformes, 10–25 µm diam; phiilaides 7.5–9 x 2–3 µm, dimumidum supremum vesiculae obtegentes. Conidio subglobosa vel ellipsoides, laevia, 1.8–1.5 µm diam. Colonieae in agaro MEA in 7 diebus et 25 °C colorante crescentes, 25–40 mm diam, albae, capitulis conidialibus paucis. Colonieae 7.5–9 x 2–3 µm, dimidium supernum vesiculae obtegentes. Conidia subglobose, 200–350 µm diam, in hyphis hyalinis vel luteoalbis laxe obtextis.
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