Synthesis of chitosan-salicylaldehyde/vanillin Schiff base as antibacterial active compound on cotton fabrics

Ismiyarto, W S Handayani, Ngadiwiyana, P R Sarjono, N B A Prasetya
Department of Chemistry, Faculty of Science and Mathematics, Diponegoro University, Jl. Prof. H Soedarto No.13, Tembalang, Semarang, Central Java, Indonesia 50275

Corresponding author: ismiyarto@live.undip.ac.id

Abstract. In this study, chitosan-salicylaldehyde/vanillin was synthesized by reflux method via condensation reaction. The aim of this study was to apply the Schiff base compound to cotton fabrics and test its antibacterial activity. The chitosan-salicylaldehyde/vanillin Schiff base was applied to cotton fabrics using spray method and antibacterial activity tested using turbidimetric method. The Schiff base was achieved with formation of brownish-yellow solids. The characterization of chitosan-salicylaldehyde Schiff base showed C=N vibration at 1649.18 cm\(^{-1}\), the ratio of Schiff base formed was 0.403 in a yield of 56% (b/b). The treated cotton fabrics using chitosan-salicylaldehyde/vanillin Schiff base showed optimum inhibition against \textit{Staphylococcus aureus} up to 69% at 6 hours and \textit{Escherichia coli} up to 7% at 18 hours.

1. Introduction
Cotton fabric is a textile material commonly used as a garment material [1] because it has absorbent power and high humidity. High absorption and high humidity make microorganisms can grow on the fabrics. Microorganisms that grow on cloth may result in a decline in the power of fibers, color fading [2] and cause irritation to the infection on the skin [3]. Applying antibacterial substance on cloth can be carried out to inhibit the growth or kill pathogenic bacteria. Chemicals formerly applied on cloth as an antibacterial is triclosan [4], but triclosan is poisonous to human and difficult to degrade by the environment [5,6,7]. Another compound that can be used as an antibacterial agent on cloth is chitosan [8].

Chitosan is a biodegradable non-toxic biopolymer, easy to degrade, and have antibacterial activity [9, 10, 11]. Antibacterial activity of chitosan is still classified as weak. Therefore, it needs to be improved by modifying the chitosan into a Schiff base (C=N) compound. A Schiff base is a compound that has C=N as its functional group resulting from a reaction between condensation of amine and the carbonyl group [12]. Chitosan Schiff bases have been reported to have antibacterial activity more vigorous than chitosan without modification. Jin et al [13] dan Barbosa et al [14] reported the successful synthesize of chitosan-salicylaldehyde schiff bases compound. Schiff bases tested its antibacterial activity and the results show antibacterial activity of chitosan Schiff bases is higher than chitosan without modification. In this study, chitosan is modified into a schiff base compound by reacting chitosan with a mixture of salicylaldehyde and vanillin. Then the base is coated on cotton fabrics to produce antibacterial cloth.
2. Research method

2.1 Materials
Chitosan, vanillin (Merck), salicylaldehyde (Merck), CH$_3$COOH 99.9% (Merck), aquadest, NaOH, ethanol, nutrient agar (Merck), pepton (Merck), yeast (Merck), amoxicillin, whatmann filter paper No.1, cotton fabrics, *Escherichia coli* and *Staphylococcus aureus*.

2.2 Equipments
A reflux instrument, bar stirrer, hot plate stirrer (VS 130 SH), desiccator, incubator (Memmert IN55), compressor ZB-0.07, spreader, viscometre ubbelohde, analytical balance (Ohaus), FTIR, UV-Vis spectrophotometer, orbital shaker, micro pipette, inoculating loop, petri dish, autoclave, laminar air flow (E-scientific) and *air brush*.

2.3 Degree of deacetylation determination
The degree of deacetylation of chitosan was determined by a baseline method comparing absorbance of amide bands and hydroxyl bands on FTIR spectra of chitosan.

2.4 Molecular weight determination
The chitosan molecular weight was measured by viscometry method. A total of 1 g of chitosan was dissolved in 100 mL of 0.2 M NaCl mixture and 0.1 M CH$_3$COOH which was then diluted to 0.0001 g/mL; 0.00025 g/mL; 0.0005 g/mL; 0.00075 g/mL and 0.001 g/mL. Solvent and chitosan solution were measured its flow time using a stopwatch with five times repeated measurements.

2.5 Synthesis of chitosan-salicylaldehyde Schiff base
Chitosan (1 g) was dissolved in 50 mL CH$_3$COOH 2% (v/v) and refluxed with 0.18 mL of salicylaldehyde at 50 °C for 6 hours. The formed product was precipitated with 5% NaOH then ethanol and distilled water. The synthesized product was dried at 60 °C. The product was characterized and analyzed by FTIR and UV-Vis spectrophotometer.

2.6 Synthesis of chitosan-vanillin Schiff base
A total of 1 g chitosan was dissolved in 50 mL CH$_3$COOH 2% (v/v) and refluxed with 0.345 g vanillin at 50 °C for 6 hours. The formed product was precipitated with 5% NaOH and continued washing using ethanol and distilled water. The synthesized product is dried at 60 °C. Product was characterized and analyzed by FTIR and UV-Vis spectrophotometer.

2.7 Synthesis of chitosan-salicylaldehyde/vanillin Schiff base
A total of 1 g chitosan was dissolved in 50 mL CH$_3$COOH 2% (v/v) and refluxed with a mixture of 0.16 mL salicylaldehyde and 0.173 g vanillin at a temperature of 50 °C for 6 hours. The formed product was precipitated with 5% NaOH and continued washing using ethanol and distilled water. The synthesized product was dried at 60 °C. The product was characterized and analyzed by FTIR and UV-Vis spectrophotometer.

2.8 Chitosan-salicylaldehyde/vanillin Schiff base coatings on cotton fabric
Cotton cloth was washed with ethanol and distilled water and dried at 80 °C. The chitosan-salicylaldehyde/vanillin Schiff base was coated on a cotton cloth by spray method and then it was dried using an oven.

2.9 Antibacterial activity test of Schiff bases
Chitosan and Schiff base solutions were tested for antibacterial activity against *Escherichia coli* and *Staphylococcus aureus* by disc diffusion method. A total of 10µL of test solution, namely CH$_3$COOH 1%, amoxicillin, chitosan, chitosan-salicylaldehyde Schiff base, chitosan-vanillin Schiff base, chitosan-
salicylaldehyde/vanillin Schiff base were tested for antibacterial activity by dropping them on disc paper on the nutrient surface and then incubated at 37 °C for 24 hours.

2.10 Antibacterial cloth activity test
Antibacterial cloth was tested for antibacterial activity against *Escherichia coli* and *Staphylococcus aureus* by the turbidimetric method. Cloth coated with Schiff chitosan-salicylaldehyde/vanillin base, fabric coated with 1% CH₃COOH and treated fabric were put into liquid media. *Staphylococcus aureus* and *Escherichia coli* bacteria with a standard of 0.5 McFarland were put into the test media and incubated for 24 hours. Measurement of optical density (OD) values was carried out at the 6th, 12th and 18th hours. The data obtained were used to calculate the percent inhibition of the growth of *Escherichia coli* and *Staphylococcus aureus*.

3. Results and discussion
Chitosan is a biopolymer that has various beneficial properties, namely biodegradable and antibacterial. The antibacterial activity of chitosan is influenced by the degree of deacetylation (DD) and molecular weight of chitosan. Chitosan with a high degree of deacetylation has a large antibacterial activity while the effect by molecular weight is the greater the molecular weight, the lower the antibacterial activity of chitosan. Determination of the degree of chitosan deacetylation is done by the baseline method based on FTIR chitosan spectra. Chitosan FTIR spectra are shown in Figure 1.

![FTIR spectrum of Chitosan](image)

Based on the spectra shown in Figure 1, a typical absorption of chitosan is found. The C=O amide group detected at wavenumber 1644.32 cm⁻¹, the C-O ether group detected at wavenumber 1074.29 cm⁻¹, the group C–H detected at wavenumber 2922.75 cm⁻¹ and -OH group detected at wavenumber 3420.43 cm⁻¹. In measuring the degree of deacetylation there are two groups that play a role in the calculation, namely the C=O and the -OH groups. The result obtained deacetylation degree of chitosan of 68.42%. The functional groups detected in chitosan IR spectra can be seen in Table 1.

| Wavenumber (cm⁻¹) | Group function          |
|-------------------|-------------------------|
| 3420,43           | Stretching O–H and N–H  |
| 2922,75           | Stretching C–H          |
| 1644,32           | Stretching C=O amide    |
| 1074,29           | Stretching C–O          |
The degree of deacetylation reflects the amount of acetyl groups lost and replaced by NH$_2$ groups. The degree of deacetylation shows the presence of NH$_2$ groups formed of 68.42% and the remaining acetyl groups of 31.58%. The chitosan molecular weight is measured using the viscometry method by measuring the chitosan flow time on the viscometer through the Mark-Houwink equation:

$$[\eta] = KM^a$$

Chitosan has molecular weight of 124926.469 g/mol with a degree of polymerization (n) of 771 monomers.

3.1 Chitosan-salicylaldehyde Schiff base

The synthesis of chitosan-salicylaldehyde Schiff base is produced from the reaction between chitosan as a nucleophile source and a mixture of salicylaldehyde and vanillin as an electrophile sources. The synthesis of chitosan-salicylaldehyde (KS) base schiffs was carried out by reacting chitosan and salicylaldehyde with different variations of the salicylaldehyde mole. Synthesis of chitosan-salicylaldehyde (KS) base obtained in the form of a brownish-yellow solid with the mass of the resulting schiff base product can be seen in Table 2.

Table 2. The mass of chitosan-salicylaldehyde (KS) base product Schiff 1-7

| No. | Sample | Salicylaldehyde (mole) | Product mass (g) |
|-----|--------|------------------------|-----------------|
| 1.  | KS 1   | 0.00040                | 1.79            |
| 2.  | KS 2   | 0.00068                | 1.82            |
| 3.  | KS 3   | 0.00121                | 2.29            |
| 4.  | KS 4   | 0.00174                | 0.95            |
| 5.  | KS 5   | 0.00227                | 1.73            |
| 6.  | KS 6   | 0.00280                | 1.71            |
| 7.  | KS 7   | 0.00333                | 2.21            |

Information:
KS : Chitosan-salicylaldehyde Schiff base

Figure 2. Chitosan-salicylaldehyde base IR spectra
Tabel 3. The chitosan and Schiff-base Schiff transmittance ratio chitosan-salicylaldehyde 1-7

| Sample | C=O:C–O–C (ratio) | C=N:C–O–C (ratio) | Schiff base ratio formed |
|--------|-------------------|-------------------|-------------------------|
| K      | 1,141             | -                 | -                       |
| KS 1   | 1,062             | 0,079             | -                       |
| KS 2   | 1,492             | -0,351            | -                       |
| KS 3   | 1,077             | 0,064             | -                       |
| KS 4   | -                 | 1,024             | 0,117                   |
| KS 5   | -                 | 1,019             | 0,122                   |
| KS 6   | -                 | 1,054             | 0,087                   |
| KS 7   | 1,233             | -0,092            | -                       |

Information: KS:Chitosan-salicylaldehyde Schiff base

The chitosan-salicylaldehyde (KS) base product was analyzed and characterized by UV-Vis and FTIR spectrophotometers. The IR spectra are shown in Figure 2. In unmodified chitosan, the C=O group was identified at wavenumber 1644 cm\(^{-1}\), while in the modified chitosan compound, the Schiff base compound, the C=N group was identified. The success of chitosan-salicylaldehyde Schiff base synthesis was demonstrated by the identification of C=N vibrations in the FTIR spectra of the compound at wavenumber 1638-1643 cm\(^{-1}\). FTIR spectra can also show the magnitude of the Schiff base ratio formed through the ratio of transmittance ratio C=N and C-O-C.

The highest KS Schiff base ratio is produced by KS 5 Schiff bases, that is 0.122. In UV-Vis analysis, chitosan and chitosan-salicylaldehyde Schiff bases produce absorption bands that show transitions \(\pi \rightarrow \pi^*\) and \(n \rightarrow \pi^*\). In chitosan, the transition \(\pi \rightarrow \pi^*\) at a wavelength of 235 nm and the transition \(n \rightarrow \pi^*\) at a wavelength of 271 nm which shows the transition of C=O groups. In comparison, in the Schiff KS base compound the transition \(\pi \rightarrow \pi^*\) occurs at a wavelength of 254-255 nm and the transition \(n \rightarrow \pi^*\) at wavelengths 291-322 nm which shows the transition group C=N. The chitosan-salicylaldehyde Schiff base was tested for antibacterial activity against the bacteria *Staphylococcus aureus* and *Escherichia coli*.

Figure 3. UV-Vis spectra of Schiff chitosan-salicylaldehyde base
Table 4. Chitosan-salicylaldehyde Schiff base inhibitory zone data

| Sample  | E. coli (12 hours) | E. coli (24 hours) | S. aureus (12 hours) | S. aureus (24 hours) |
|---------|-------------------|-------------------|-------------------|-------------------|
| K       | 5                 | 4                 | 8                 | 5                 |
| KS 1    | 5                 | 4                 | 7                 | 3                 |
| KS 2    | 6                 | 5                 | 8                 | 4                 |
| KS 3    | 7                 | 6                 | 7                 | 3                 |
| KS 4    | 7                 | 5                 | 7                 | 3                 |
| KS 5    | 8                 | 7                 | 9                 | 8                 |
| KS 6    | 6                 | 4                 | 8,5               | 4                 |
| KS 7    | 6                 | 4                 | 8                 | 4                 |
| +       | 24                | 23                | 19                | 13                |
| -       | 4                 | 3                 | 5                 | 1                 |

Information:

K : Chitosan
KS : Chitosan-salicylaldehyde Schiff base
+ : Amoxicillin
- : Acetic Acid

3.2 Chitosan-vanillin Schiff base

The chitosan-vanillin Schiff base was synthesized by reacting chitosan with vanillin. In the reaction, the carbonyl group (C=O) vanillin acts as an electrophile and the primary amine (NH₂) chitosan acts as a nucleophile. The success of the synthesis was proven by the identification of the C=N group in the chitosan-vanillin Schiff base FTIR spectra. The FTIR results showed that functional groups were detected in KV schiff base compounds.

Figure 4. Chitosan-vanillin Schiff base IR spectra
Table 5. Interpretation of chitosan-vanillin Schiff base IR spectra

| Wavenumber (cm⁻¹) | Functional groups       |
|-------------------|-------------------------|
| 3407.87           | Stretching O-H and N-H  |
| 2925.23           | Stretching sp³ C-H      |
| 1645.85           | Stretching C=N          |
| 1425.80           | Stretching C-C aromatic |
| 1073.79           | Stretching C-O          |
| 896.82            | Aromatic substituent    |

The clusters identified in the chitosan-vanillin Schiff base FTIR spectra can be seen in Table 5. FTIR-chitosan-vanillin base FTIR spectra produce absorption bands at wavenumbers 3407.87 cm⁻¹ indicating O-H and N-H absorption, while at wavenumbers 1645.85 cm⁻¹ shows absorption of C=N on Schiff base compounds KV. The existence of other functional groups such as C–O–C, aromatic C–C, C–H sp³ and C–H sp² in the Schiff base KV were identified at wavenumbers 1073.79 cm⁻¹, 1425.80 cm⁻¹, 2925.23 cm⁻¹ and 896.82 cm⁻¹. In addition to show the functional groups found in the chitosan-vanillin base Schiff, FTIR spectra were able to show the ratio of the Schiff bases formed through the ratio of C=N/C–O-C transmittance and the results of 0.0814. The success of the synthesis was analyzed with a UV-Vis spectrophotometer.

Figure 5. Schiff chitosan-vanillin base UV-Vis spectra

Table 6. Interpretation of UV-Vis spectra of Schiff-vanillin Schiff bases

| Peak | Wavelength (nm) | Transition       |
|------|-----------------|-----------------|
| I    | 273,103         | \(\pi \rightarrow \pi^*\) C=O group |
| II   | 313,622         | \(\pi \rightarrow \pi^*\) C=N group |
| III  | 280,859         | \(n \rightarrow \pi^*\) C=N group |

The \(\pi \rightarrow \pi^*\) C=O transition was detected at a wavelength of 273,103 nm which is a transition from chitosan, while C=N was detected at a wavelength of 313,622 nm and the transition \(n \rightarrow \pi^*\) was detected at a wavelength of 380,859 nm which is the transition from Schiff chitosan base compounds–Vanillin. Schiff base products are formed in the form of brownish yellow solids with a yield of 63% (w/w).
3.3 Chitosan-salicylaldehyde/vanillin Schiff base

Synthesis was carried out by reacting chitosan with a mixture of salicylaldehyde and vanillin (1:1). Chitosan acts as a nucleophilic while salicylaldehyde and vanillin act as electrophiles. The success of the formation of the Schiff base is viewed from the results of the FTIR spectrum analysis.

![Figure 6. Chitosan IR spectra and Schiff base compounds](image)

**Figure 6.** Chitosan IR spectra and Schiff base compounds

| Wavenumber (cm⁻¹) | Functional group                  |
|-------------------|-----------------------------------|
| 3444,53           | Stretching O-H dan N-H            |
| 2889,72           | Stretching sp3 C-H                |
| 1649,18           | Stretching C=N                    |
| 1378,83           | Stretching C-C aromatic           |
| 1068,24           | Stretching C-O                    |
| 896,82            | Aromatic subsituent               |

**Table 7.** Interpretation of chitosan-salicylaldehyde/vanillin Schiff base IR spectra

![Figure 7. Schiff chitosan-salicylaldehyde/vanillin base Schiff UV-Vis spectra](image)

**Figure 7.** Schiff chitosan-salicylaldehyde/vanillin base Schiff UV-Vis spectra
The groups that obtained chitosan-salicylaldehyde/vanillin Schiff base spectra are O-H and N-H identified at wavenumber $3444.53 \text{ cm}^{-1}$, $\text{C}=\text{N}$ at wavenumber $1649.18 \text{ cm}^{-1}$ which is one of the specific characteristics from the Schiff base, $\text{C}==\text{C}$ at wavenumber $1378.83 \text{ cm}^{-1}$, $\text{C}-\text{O}-\text{C}$ at wavenumber $1068.24 \text{ cm}^{-1}$ and the aromatic substituents identified at wavenumber $896.82 \text{ cm}^{-1}$.

The peaks show the transition $\pi \rightarrow \pi^*$ which occurs at $\text{C}=\text{O}$ at a wavelength of $249,941 \text{ nm}$ which is the transition from chitosan, the second peak shows the transition $\pi \rightarrow \pi^*$ at a wavelength of $286,078 \text{ nm}$, while the third peak shows the transition $n \rightarrow \pi^*$ at a wavelength of $394,105 \text{ nm}$ which is the transition $\text{C}=\text{N}$. Schiff bases formed in the form of brownish yellow solids with a yield of $56\%$ (w/w) and the ratio of the formed Schiff bases is equal to $0.403$.

| Peak | Wavelength (nm) | Transition |
|------|-----------------|------------|
| I    | 249,491         | $\pi \rightarrow \pi^*$ $\text{C}=\text{O}$ group |
| II   | 286,078         | $\pi \rightarrow \pi^*$ $\text{C}=\text{N}$ group |
| III  | 394,105         | $n \rightarrow \pi^*$ $\text{C}=\text{N}$ group |

3.4 Antibacterial activity test of Schiff base compounds

Schiff base compounds are tested for the growth of two types of bacteria, namely *Staphylococcus aureus* (Gram-positive) and *Escherichia coli* (Gram-negative). Chitosan and its Schiff bases produce a better inhibitory activity on the bacteria *S. aureus* (G +) This result is indicated by a barrier zone that is generated larger than the inhibitory zone of *E. coli* (G-) in both the hour of the 12th, as well as in the 24th hour. This occurs because of the difference in antibacterial sensitivity that influenced by different cell wall arrangement. *S. aureus* has a single layered cell wall with a lipid content of 1-4%, whereas *E. coli* has a more complex cell wall with a lipid content of 11-22%, consisting of lipoproteins, outer membranes of phospholipids, and Lipopolysaccharides (Poeloengan and Praptiwi, 2010).

![Figure 8. Inhibition zone of Schiff base compound](image-url)
**Table 9.** Inhibition zone diameter of Schiff base compound

| Sample | Inhibition zone diameter (mm) | Escherichia coli (G−) | Staphylococcus aureus (G+) |
|--------|-------------------------------|-----------------------|---------------------------|
|        | 12th hours | 24th hours | 12th hours | 24th hours |
| K      | 6          | 4          | 7          | 6          |
| KS     | 7          | 5          | 8          | 7          |
| KV     | 6          | 5          | 8          | 7          |
| KSV    | 8          | 7          | 9          | 8          |
| +      | 22         | 22         | 18         | 4          |
| -      | 4          | 3          | 5          | 3          |

Information:

- K: Chitosan
- KS: Chitosan-salicildehyde Schiff base
- KV: Chitosan-vanillin Schiff base
- KSV: Chitosan-salicildehyde/vanillin Schiff base

3.5 *Antibacterial activity test of antibacterial cotton fabrics*

Cotton fabrics coated with a Salicylaldehyde/Vanillin was tested with the Turbidimetry method. Antibacterial activity measured based on the value of OD to the growth of *Staphylococcus aureus* and *Escherichia coli* in the 6th, 12th, and 18th hours.

![Percent inhibition of Antibacterial Cotton Fabrics against S. aureus](image)

**Figure 9.** Percent inhibition of *S. aureus*

Cotton fabrics coated with a Chitosan–Salicylaldehyde/Vanillin Schiff base indicate the greatest percent of inhibition compared to others. The largest inhibition occurred at the 6th hour of 69% and at an 12th hour of 48% while in a cloth coated in acetic acid 1% acquired percent inhibition by 8% at the 18th hour.

Cotton fabrics coated chitosan-salicildehyde/vanillin Schiff base suggests the optimum inhibition of bacterial growth *E.coli* is at the 18th hour, while for the previous hour the ability of a base cloth coated with chitosan–salicildehyde/vanillin Schiff base inhibits the growth of still slow bacteria that is 5% both at the 6th hour, as well as during the 12th hour. In a fabric coated in acetic acid 1% the greatest inhibition capability occurs in the 6th hour of 8%, while the next hour of inhibitory activity on the growth of *E. coli* bacteria decreases.
 Conclusion
The chitosan which is used as a base material of the base Schiff has a degree of deacetylation of 68.42% with a molecular weight of 124928.62 g/mol (n = 771). The alkaline compounds of Schiff chitosan–vanilin (KV) produce a product with a base ratio of Schiff formed 0.0814 with a yield of 63%. The alkaline compounds of Schiff chitosan–salicylaldehyde/vanillin (KSV) produce a product with a base rate of Schiff formed 0.403 with a 56% yield. The coated cloth base Schiff chitosan – salicylaldehyde/vanillin indicates an inhibition of the optimum growth of S. aureus in the 6th hour with a percent inhibition of 69% and E. coli which is optimum at the 18th hour with a percent inhibition of 7%.

Acknowledgement
This research was funded through the RPP Research Fund, Diponegoro University 2020, with Number: 233-114 / UN7.6.1 / PP / 2020.

References
[1] Herjanto E 2007 Jurnal Standardisasi 9 116 122
[2] Winiati W, Kasipah C, Yulina R, Wahyudi T, Mulyawan A S and Septiani W 2014 Arena Tekstil 29 1
[3] Abo-Shosha M, El-Hosamy M, Hashem A and El-Nagar A 2007 J. Ind. Text. 37 1 55-77
[4] Orhan M, Kut D and Gunesoglu C 2007 Indian J. Fibre Text. Res. 32 114-118
[5] Chen X, Nielsen J L, Furgal K, Liu Y, Lolas I B and Bester K 2011 Chemosphere 84 4 452-456
[6] Coogan M A, Edziyie R E, La Point T W and Venables B J 2007 Chemosphere 67 10 1911-1918
[7] Vigo T 1983 Protection of Textiles from Biological Attack. Handbook of Fiber Science and Technology: Chemical Processing of Fibers and Fabrics, Functional Finishes Part A (New York: Marcel Dekker)
[8] Zhang Z, Chen L, Ji J, Huang Y and Chen D 2003 Text. Res. J. 73 12 1103-1106
[9] Lim S H 2003 Synthesis of a Fiber-Reactive Chitosan Derivative and Its Application to Cotton Fabric as an Antimicrobial Finish and a Dyeing-Improving Agent Dissertation (North Carolina: North Carolina State University)
[10] Muzzarelli R 1977 Chitin (New York: Pergamon Press)
[11] No H K, Park N Y, Lee S H and Meyers S P 2002 Int. J. Food Microbiol. 74 65-72
[12] Cimerman Z, Galic N and Bosner B 1997 Analytica Chimica Acta 343 145-153
[13] Jin X, Wang J and Bai J 2009 Carbohydr. Res. 344 825-829
[14] Barbosa H, Attioui M, Ferreira A, Dockal E, El-Gueddari N, Moerschbacher B and Cavalheiro E 2017 Molecules 22 11 1987

Figure 10. Percent inhibition E. coli

4. Conclusion

The chitosan which is used as a base material of the base Schiff has a degree of deacetylation of 68.42% with a molecular weight of 124928.62 g/mol (n = 771). The alkaline compounds of Schiff chitosan–vanilin (KV) produce a product with a base ratio of Schiff formed 0.0814 with a yield of 63%. The alkaline compounds of Schiff chitosan–salicylaldehyde/vanillin (KSV) produce a product with a base rate of Schiff formed 0.403 with a 56% yield. The coated cloth base Schiff chitosan – salicylaldehyde/vanillin indicates an inhibition of the optimum growth of S. aureus in the 6th hour with a percent inhibition of 69% and E. coli which is optimum at the 18th hour with a percent inhibition of 7%.