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SPECIFIC BENDING AND COMPRRESSIVE STRENGTH OF POLY(VINYL ALCOHOL)-CNT COMPOSITES

Carbon nanotubes are one of the strongest materials of unique mechanical, optical, electrical and electronic properties. Because of that they are mainly used as semiconductor materials constituting the reinforcing phase in composite materials.

The paper presents properties of polymer composites reinforced with carbon nanotubes (CNT) containing various mixtures of dispersion. Produced composites featured various content carbon nanotubes: 20%, 30%, 40% i 50%. Macroscopic observations were carried out on ready to check composites, if pores exist in the structure and whether the reinforcement has been distributed in the entire volume. Bending and compressive strengths tests were performed and densities of individual composites were measured to determine the specific strength.

Composite materials strengthened with carbon nanotubes feature a very low density and a very good mechanical strength, which makes them a good structural material.

Keywords: carbon nanotubes, composites, mechanical strength, density

2. Material and experimental methods

CNT CO. LTD carbon nanotubes, with commercial name CTUBE 100, obtained using the thermal CVD method and polyvinyl alcohol with a water acrylate dispersion were used as the studied materials. As received CNTs were 1 to 25 μm long, 10 to 40 nm in diameter, with the bulk density of 0.03-0.06 g/cm³, purity >93% and the specific surface area of 150-250 m²/g.

Polyvinyl alcohol (PVA) with a water acrylate dispersion was used as the matrix.

Composites were produced using the solvent method, i.e. via mixing in the solution. Carbon nanotubes used for the reinforcement of composites were not pre-treated or modified. In the first stage both polymers (PVA and acrylate) were blended and then an appropriate amount of carbon nanotubes has been added. The whole was mechanically mixed during 0.5 h to disperse carbon nanotubes well in the polymer. After spontaneous evaporation of the solvent, composites were crosslinked at room temperature during 30 days.

Composites containing from 20 to 50% of CNT were produced. All composites featured a low density. The method of density measurement consists of independent measurement.

The paper presents the influence of carbon nanotubes content on strength properties of polymer nanocomposites and on their density.
of specimen’s mass and volume. The mass of specimens was determined by means of an electronic balance (Δ ± 0.01 g) and the volume of cuboidal specimens via measuring their dimensions using a vernier caliper (Δ ± 0.01 mm).

Two types of specimens were prepared: 10 mm × 10 mm × 60 mm and 10 mm × 10 mm × 30 mm used for three-point bending and compressive strength test respectively. The tests were carried out using a ZWICK/ROELL Z100 testing machine with the load cell capacity of 50 kN.

3. Results of Tests

Macroscopic observations were carried out on finished composites using an Olympus ZS61 stereoscopic microscope (Fig. 1). It can be seen, the reinforcement is distributed throughout the entire matrix volume. Pores are visible in the composites, which could have originated during self-evaporation of the solvent. Also nanotubes agglomerates, which have not been well dispersed, are visible in the structure of composite.

![Fig. 1. Macroscopic structure individual composites: a) 20% CNT; b) 30% CNT; c) 40% CNT; d) 50% CNT](image)

The density was the next determined parameter. The composites density is pretty low, which makes them light and strong. For the composite with 20% reinforcement content the density was 0.47 g/cm³, for the composite with 30% reinforcement content – 0.42 g/cm³. Lower density have composite with 40% reinforcement content – 0.31 g/cm³ and composite with 50% reinforcement content is 0.23 g/cm³.

The curves shows in Fig. 2 were obtained during a three-point bend test, based on which the specific bending strength was determined for individual composites.

Curves of composites compression test (Fig. 3) allowed to determine the specific compressive strength (Fig. 4).

The specific strength is a significant indicator for the strength determination. Both specific bending and compressive strengths were determined based on the results obtained from mechanical and physical tests (Fig. 4).

Composites with the nanotubes content of 30% and 40% were characterised by the highest specific bending and compressive strength. The composite containing 30% of carbon nanotubes has the specific bending strength of 6.33 MPa and compressive strength of 6.6 MPa, while the composite containing 40% of carbon nanotubes features the specific bending strength of 4.10 MPa and compressive strength of 5.87 MPa.
4. Summary of results

The paper presents the method for obtaining polymer-carbon nanotube composites and their properties. The produced composites have a low density (from 0.23 g/cm$^3$ to 0.47 g/cm$^3$), which makes them a very light material, capable of applying as a structural material. Pores in composites decreasing their strength properties. In the next processes of composites production pores will be eliminated. To be fully utilized in the industry composites must additionally have a high mechanical strength. In our research we have been looking for an appropriate acrylate, to obtain a composite competing with properties of aluminium.

Composites presented in the paper feature a specific bending strength ranging from 2.28 MPa to 6.33 MPa and a specific compressive strength from 3.49 MPa to 6.6 MPa.

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