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WATER ABSORPTION IN CARBOXYMETHYL CELLULOSE

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Abstract:

The paper deals with the testing of carboxymethyl cellulose properties. It was verified whether carboxymethyl cellulose soaked in water, salt solution or pH adjusted water resulted in better sorption properties than 100% cellulose represented by standardised cotton fabric. During the measurements the samples were dipped into water of different temperatures (10 °C, 20 °C, 30 °C, 40 °C, 50 °C), in a NaCl solution (concentration 0.1g/l, 0.9 g/l, 5 g/l and 10 g/l) and in water with a modified pH (5, 7, 9). Another measure was aimed at monitoring changes in the structure of the textile samples soaked in water at a temperature of 20 °C with subsequent drying, which was carried out using an electron microscope.

Key words:

Carboxymethyl cellulose, immersing, sorption properties, structure.

Introduction

Cellulose

Cellulose is the most common organic substance on earth. Photosynthesis annually creates huge amounts. Even as an industrial raw material it belongs to the basic. Annually, it consumes almost as much as grain or oil. The elemental composition of cellulose is 44.4% C, 6.17% H and 49.39% O, resulting in the formula $(C_6H_{10}O_5)n$. The same molecular formula also refers to other polysaccharides, such as starch. Cellulose contains six-carbon cycles, called pyranose. The structure of pyranose is shown in Figure 1 [1,2]. Binding of several thousand (3000–15000) basic units of β-glucose forms cellulose macromolecule. Each β-glukopyranose unit includes 3 alcohol groups. The main reactions that affect the structure of cellulose and cause structural changes are photodegradation, acid hydrolysis, oxidation and biodegradation [3,4]. Technically they are important derivatives of cellulose esters and cellulose ethers. Cellulose derivatives distinguish the type of reaction of the hydroxyl group [5].

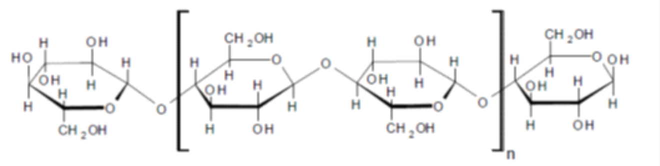

Figure 1. Structure of pyranose

Carboxymethyl cellulose (CMC)

Carboxymethyl cellulose is a derivative of cellulose obtained by the chemical modification of natural cellulose. CMC is generally prepared through the reaction of alkali cellulose with monochloroacetate or its sodium salt in an organic medium. The greater part of CMC, which contains 40% moisture, is further processed by drying [6]. Carboxymethyl cellulose has many desirable applications, such as in coatings, the formation of emulsions and suspensions, and for water retention. Therefore it is used in many applications such as medicine, food, paper making, printing and dyeing. Carboxymethyl cellulose is used as a protective colloid thickener and in dispersion in aqueous solvents. It is also an aid in the production of NH and adhesives. Sodium salts of carboxymethyl cellulose form the basis for the production of cellophane. The disadvantage of CMC is its low resistance to rot, insects and light. Carboxymethyl cellulose is also used for thickening foods such as in the manufacture of ice cream, syrups, puddings, etc. The molecular structure of carboxymethyl cellulose is shown in Figure 2 [7,8]. Carboxymethyl cellulose was first produced in Germany in the 1930s. Since 1947, it was manufactured in the USA. It was used for the production of synthetic laundry detergent. Meanwhile CMC began to be used in many other industries.

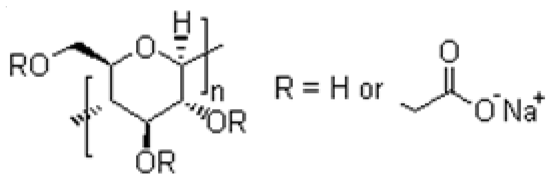

Figure 2. Molecular structure of carboxymethyl cellulose.

Experimental

Materials

CMC – cotton nonwoven fabric 60g/m2 (pH 6,8).
Cotton – standardised cotton fabric for fastness testing 12.5 g/m^2 (Czech Standard 80 01 01).

Method used

Measurement of mass growth

Measurements consisted in immersing samples of approx. 0.1 g in water with an adjusted concentration of NaCl, pH and temperature. Samples were immersed in liquids for a defined time. Samples were weighed dry before soaking and then again after soaking. The weighing was done on analytical balances. The calculation of the increase in weight after soaking was made in grams and percentages. The calculation is shown in the equation (1) below. The samples were dipped in distilled water of different temperature (10°C, 20°C, 30°C, 40°C, 50°C), in NaCl solutions (concentration 0.1g/l, 0.9 g/l, 5 g/l and 10 g/l) and in pH adjusted water (5, 7, 9).

$$W = \frac{x - y}{y} \cdot 100\%$$

Where: x - height after immersion (g), y - original weight (g), W - mass growth (%), y - original weight (g).

Observed changes in the structure of textile samples

Changes observed in the structure of textile samples soaked in water at a temperature of 20°C with subsequent drying were determined using an electron microscope. It measured 20 fibre diameters for each image with a resolution of 500. The values of the 20 samples established the average, and the coefficient of variation and standard deviation were calculated.

Results

Mass growth - effect of water temperature

The graphs show that increases in the weight of the samples are almost constant as a function of time and water temperature. The CMC sample has values nearly eight times higher than the standard cotton sample.

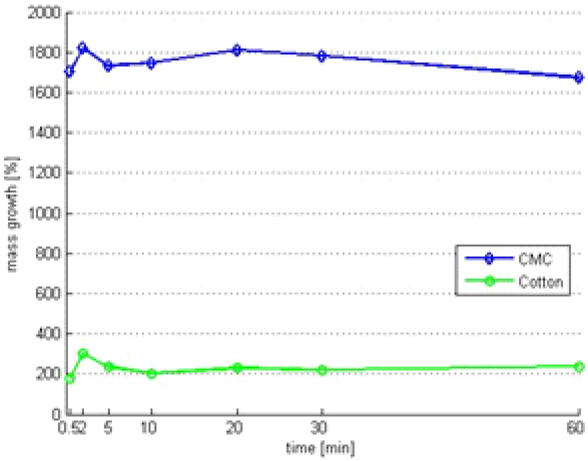

Figure 3. Average values of mass growth gain after immersion in water at a temperature of 10°C (dependent on time).

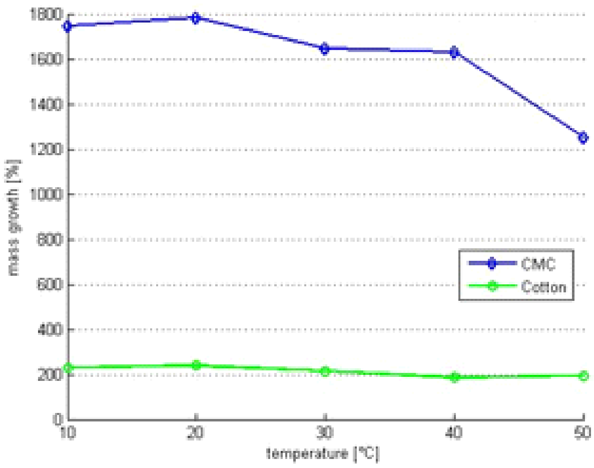

Figure 4. Values of mass growth gain after immersion in water (dependent on the temperature of the water).

Mass growth - effect of NaCl concentration and pH of water

Figure 5 shows that an increase in weight after immersion in NaCl is evident, and that with an increasing concentration of NaCl solution into which the samples were dipped, weight gain in a sample of CMC decreases. The weight gain in the sample of standard cotton is unchanged with relation to the concentration of the NaCl solution.

The chart shows that increases in weight after immersion in pH adjusted water with respect to immersion time are almost constant. Sample of CMC again reaches values almost eight times higher than the sample of standard cotton.

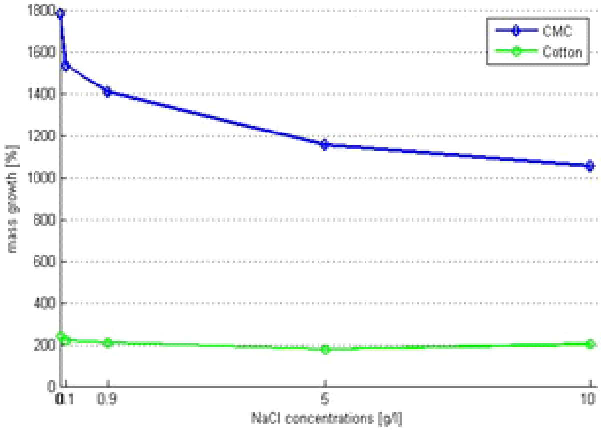

Figure 5. Averages of mass growth after immersion in NaCl.

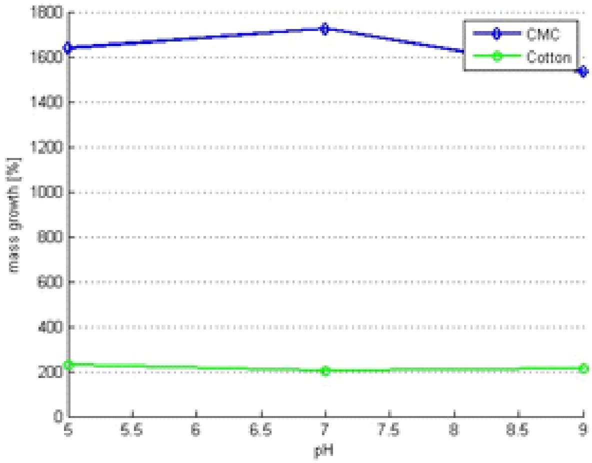

Figure 6. Values of mass growth after immersion in pH adjusted water.

Changes in the structure of textile samples

Images from the electron microscope are shown below (Figures 7 to 10).

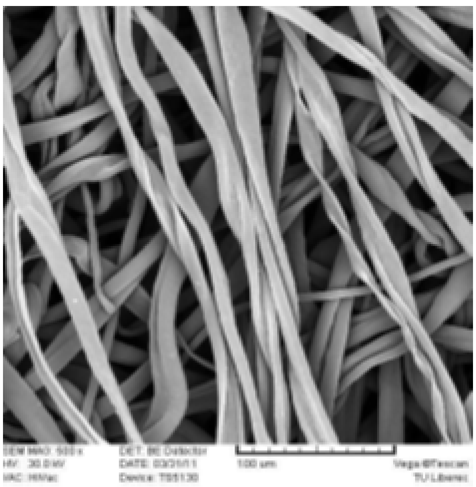

Figure 7. Image of CMC before immersion.

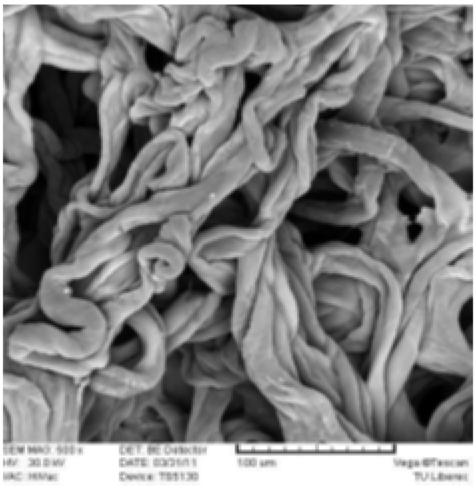

Figure 8. Image of CMC after immersion and drying.

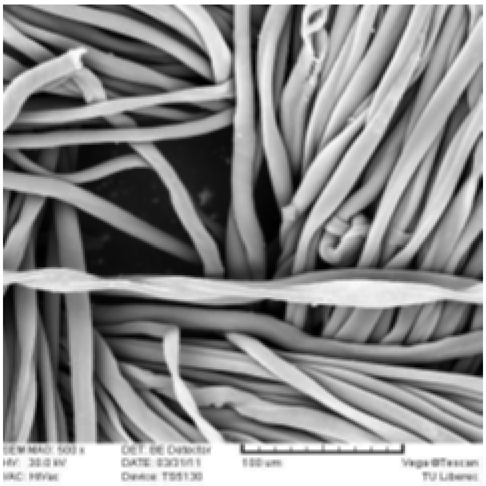

Figure 9. Image of standardised cotton before immersion.

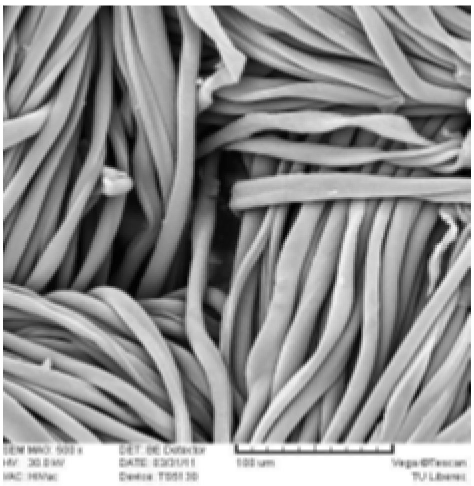

Figure 10. Image of standardised cotton after immersion and drying.

Measurement of diameter

Statistical values of samples before soaking and after soaking are shown in Table 1 and Table 2.

The images show that the CMC is due to swelling when wet diameter increases. This also changes the structure, more precisely the combined swelling, distortion and shrinkage of

Table 1. CMC

Sample	$\overline{x}$ [μm]	s [μm]	V [%]
Parameters before immersion	6.9	1.7	25.0
Parameters after immersion and drying	10.2	2.4	24.0

Table 2. Standardised cotton.

Sample	$\overline{x}$ [μm]	s [μm]	V [%]
Parameters before immersion	6.0	1.3	21.0
Parameters after immersion and drying	6.0	1.1	18.0

the fibres. The CMC increases by an average of 48%. The there is no change in the diameter or structure of the standard cotton sample after soaking.

Conclusion

This work focused on the testing of the properties of carboxymethyl cellulose. It was verified whether carboxymethyl cellulose immersed in water, salt solution or pH adjusted water resulted in better sorption properties than 100% cellulose represented by standardised cotton fabric. During the measurements the samples were dipped into water at different temperatures (10°C, 20°C, 30°C, 40°C, 50°C), in NaCl solutions (concentration 0.1g/l, 0.9 g/l, 5 g/l and 10 g/l) and in water with a modified pH (5, 7, 9). Another measure was aimed at monitoring changes in the structure of the textile samples soaked in water at a temperature of 20°C with subsequent drying, which was examined using an electron microscope. During immersion in water the CMC samples had values of mass growth nearly eight times higher than the standard cotton samples, and the increase in the weight of the samples are almost constant as a function of time and water temperature. With the increasing concentration of NaCl solution into which the samples were dipped, the weight gain in a sample of CMC decreases. The standard cotton sample's weight gain dependent on the concentration of NaCl solution is unchanged. Increases in weight after immersion in the pH adjusted water with respect to immersion time are almost constant. The samples of CMC obtain values almost eight times higher than the samples of standard cotton. The CMC samples structures changed after immersion in water followed by drying, and its diameter increased by up to 48%. The standardised cotton sample did not show any changes in structure or increase in diameter. The measurement results show that due to its high swelling the samples of CMC are suitable, not only for medical, but also for technical applications. The results of this work serve as a basis for understanding the properties and behaviour of the samples examined.

Acknowledgement

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