THE EFFECT OF PREPARED SAMPLES OF SEQUESTRATE AGENTS AND CHELATING SURFACTANTS ON THE MODEL WASHING

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***Abstract**: In this work presents the results of model washing with addition of prepared samples of sequestering agents and chelating surfactants. After 20× repeated washing in hard water of 22 °dH (given in German degrees of hardness) were determined the content of ash and Ca^{2+} ion. The image of fabric after the model washing was evaluated by means of images from a scanning electron microscope.*
***Key words**: sequestrate agents, chelating surfactants, washing of textile materials*

1 INTRODUCTION

It is well known, that water has irreplaceable role in textile industry. Any textile production is dependent on water and sufficiency of water with good quality and it is a basic precondition for textile plants. Water is almost the only solvent, which is used in textile industry for washing and dissolution of finishing agents, dyes and sizes and it also is used for steam production.
The washing is one of the most important activities in the treatment and maintenance of textiles. The detergent is a complex mixture containing various systems – surfactants, builders and auxiliary agents.
An adverse effect of alkaline earth metal ions (Ca^{2+}, Mg^{2+}), which make water hardness and also the effect of heavy metal ions (Fe^{3+}, Cu^{2+}, Mn^{2+}) on fundamental processes of textile industry has been generally well known. An important property of sequestrates is disabling of $CaCO_3$ precipitation. This slightly soluble compound precipitates at high temperature as water stone on equipment and may affect its functioning, temperature regime etc. Besides of this, $CaCO_3$ can deposit on treated textile causing a rough handle. It also affects an efficiency of textile auxiliary agents and a run of other textile finishing processes. Besides $CaCO_3$, a negative effect can also have calcium silicate, which is created it water glass is present.
Therefore the usage of sequestrate agents is recommended even in pre-treatment. Sequestrates are the most frequent agents used as components of detergents, not only in areas of textile finishing (mainly in pre-treatment) but also in further areas, e.g. dyeing cellulose materials and water softening. Sequestering agents are generally compounds creating chelates, what are specific kinds of complex compounds surrounding the cation.
The chelating surfactants should combine the properties of surfactants and sequestering agents. Then the sequestering substance reduces the hardness of the water and improves washing effect of surfactants. [1, 2, 3]
New types of sequestering agents and chelating surfactants (derivatives of aspartic acid) were synthetized at Institute of Chemistry and Technology of Macromolecular Material of University of Pardubice. Prepared samples are biodegradable. [4] These substances were tested at repeated model washing in hard water.

2 EXPERIMENTAL

The samples of sequestering agents and chelating surfactants

Two types of sequestering agents (Tab. 1) and three types of chelating surfactants (Tab. 2) were tested in this study. The commercial sequestering agent Trilon M (Tab. 1) was used for the comparison of their efficiency.

Table 1 Structures of sequestering agents

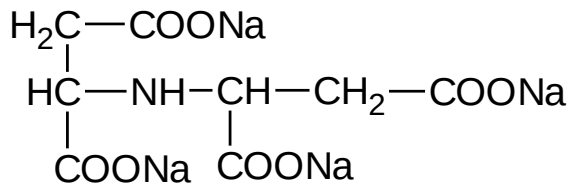
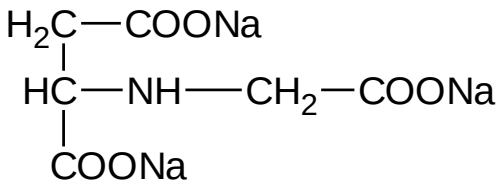
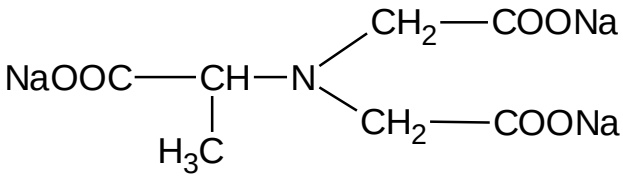
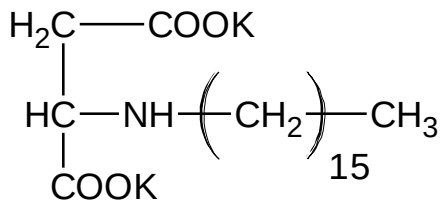
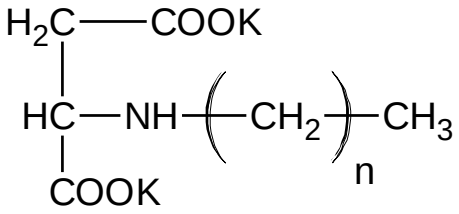
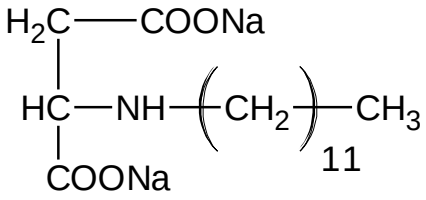
Sample	Chemical structure
No. 1	 *N*-(1,2-dicarboxyethyl)aspartic acid tetrasodium salt
No. 2	 *N*-carboxymethyl aspartic acid trisodium salt
Trilon M	 methylglycindiacetic acid trisodium salt

Table 2 Structures of chelating surfactants

Sample	Chemical structure
No. 3	 *N*-hexadecyl aspartic acid dipotassium salt
No. 4	 n = 10-18 *N*-cocoyl aspartic acid dipotassium salt
No. 5	 *N*-dodecyl aspartic acid disodium salt

The model washing process

Prepared agents were determined under conditions for model washing. The model detergent chosen consisted of water glass (soln. of sodium metasilicate), carboxy-methylcellulose, sodium carbonate, and sodium sulfate [5]. The sequestrates determined were added into this basic mixture, when the washing filling had contained 7 g/l model washing agent. The washing material was then a portion of 20 grams of cotton textile, at a bath ratio of 1:20.

The washing was repeated 20x in hard water 22 °dH (given in German degrees of hardness) for 30 min at 90 °C (Fig.1). The hard water was prepared by dissolving $CaCl_2.6\ H_2O$ in distilled water (1°dH = 39,06 mg $CaCl_2$. 6 H_2O).

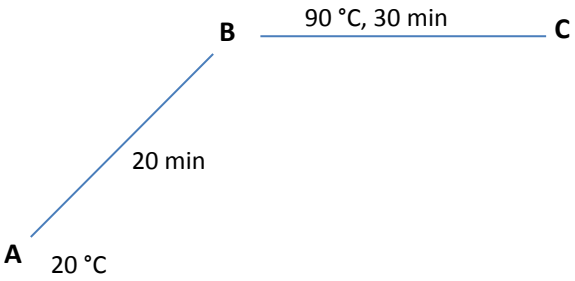


Figure 1 Process of model washing

The evaluation of content of ash and Ca^{2+} ions

After 20× repeated washing in hard water of 22 °dH for 30 min at 90 °C, the content of ash and Ca^{2+} ion were determined. After 20× repeated washing, the textile was incinerated in a platinum crucible and the amount of calcium was evaluated in ash. The titration was accomplished with Chelaton III (13.270 g/l) according to the recommended procedure [6]. Finally, the image of fabric after the model washing was evaluated by means of images from a scanning electron microscope (JEOL JSM – 5500LV).

3 RESULTS AND DISCUSSION

Due to the fact that the significant part of the world production of the sequestrate agents is used for manufacturing of detergents and the cleaning agents, the samples prepared were tested at model washing conditions. The washing with model detergent without sequestering ingredients increased the content of inorganic deposits in cotton textile. The content of ash and calcium in textile is relatively high: 3.18 % ash and 15.20 g/kg Ca^{2+}. The addition of prepared samples with sequestrate effect improved the result as documented by the data in Table 3.
Reduction of the content of ash and calcium was observed mainly by typical sequestering agents (Trilon M, sample no.1, sample no.2). The lowest content of Ca^{2+} shows sample no. 1 N-(1,2-dicarboxyethyl)aspartic acid tetrasodium salt - see Fig.4.
With ingredient of chelating surfactants is content of ash and calcium lower than without prepared samples, too. Measured values are higher than for sequestrate agents. Whereas chelating surfactants have lower value of the sequestering capacity, the combination with sequestering agent was performed. These combinations were achieved best result by surfactants prepared from cocoylamin (sample no.4). The combinations with sample no.5 do not lead better results. Synergic effect is not occurred. The reason may be a influence of dispersion and solubilization. The combination of sample no. 4 with Trilon M has the best effect in the bath: 0,02 % ash and 0,11 g/kg Ca^{2+}.

Table 3 Content of ash and calcium ion in the cotton textile after twenty times repeated washing in hard water 22°dH

Sample	Ash content (mass %)	Content of Ca^{2+} (g / 1kg)
no. 1 + model detergent	0,08	0,08
no. 2 + model detergent	0,50	1,76
no. 3 + model detergent	0,50	1,87
no. 4 + model detergent	1,08	4,22
no. 5 + model detergent	1,14	4,81
Trilon M + model detergent	0,06	0,43
no. 5 + no. 1 (2 : 1) + model detergent	1,80	7,83
no. 5 + no. 2 (2 : 1) + model detergent	1,91	7,97
no. 5 + Trilon M (2 : 1) + model detergent	1,30	5,11
no. 4 + no. 1 (2 : 1) + model detergent	0,66	2,67
no. 4 + no. 2 (2 : 1) + model detergent	0,96	3,90
no. 4 + Trilon M (2 : 1) + model detergent	0,02	0,11
Washing without sequestrate agents	3,18	15,20
Commercial washing agent Bonux	5,30	16,70
Commercial washing agent Colon	4,55	18,50

The image of fabric after the model washing was evaluated by means of images from a scanning electron microscope (Fig. 2 – 10). With the addition of agent with sequestrate, the resultant effect was improved, which was the case of the commercial washing agents, too.

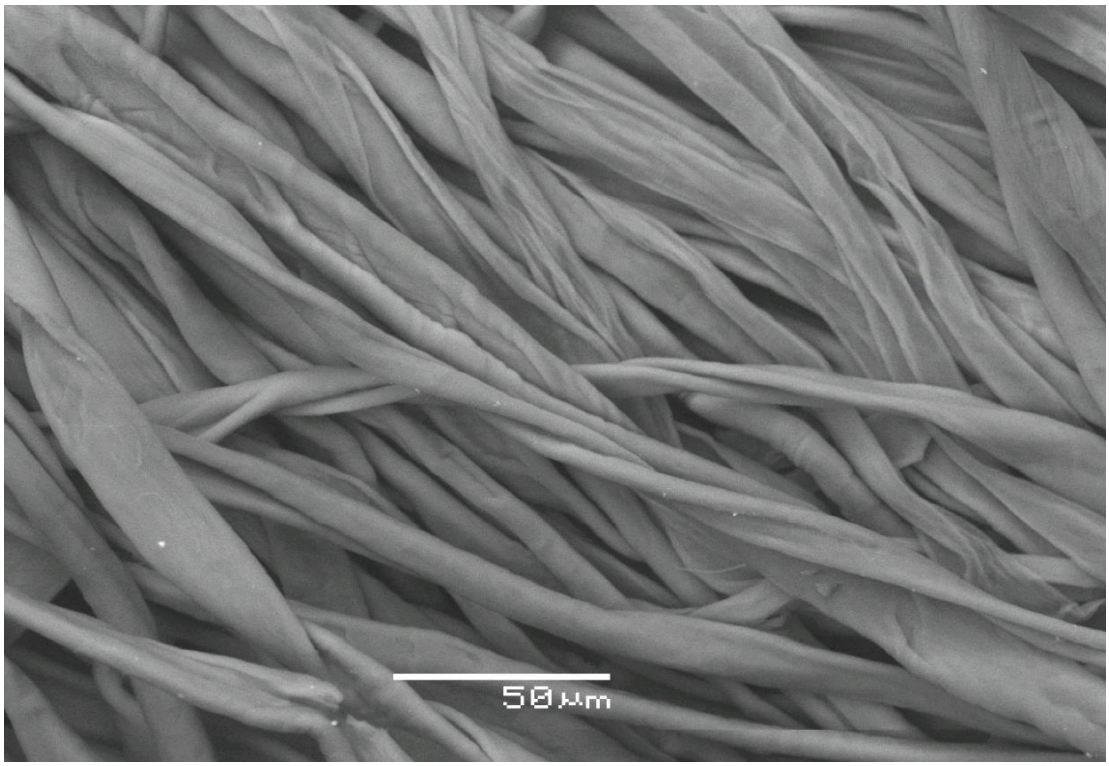


Figure 2 EMS of fiber surface of cotton textile (magnification 500x)

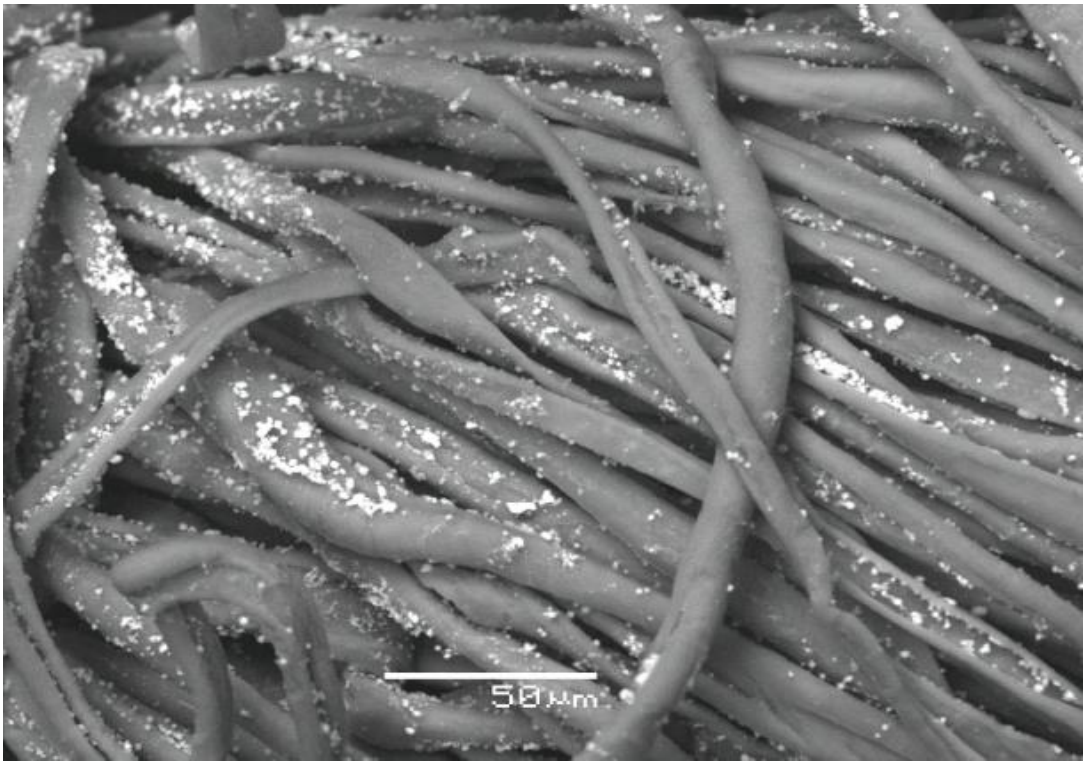


Figure 3 EMS of fiber surface of cotton textile washed without sequestering agent with model detergent (magnification 500x)

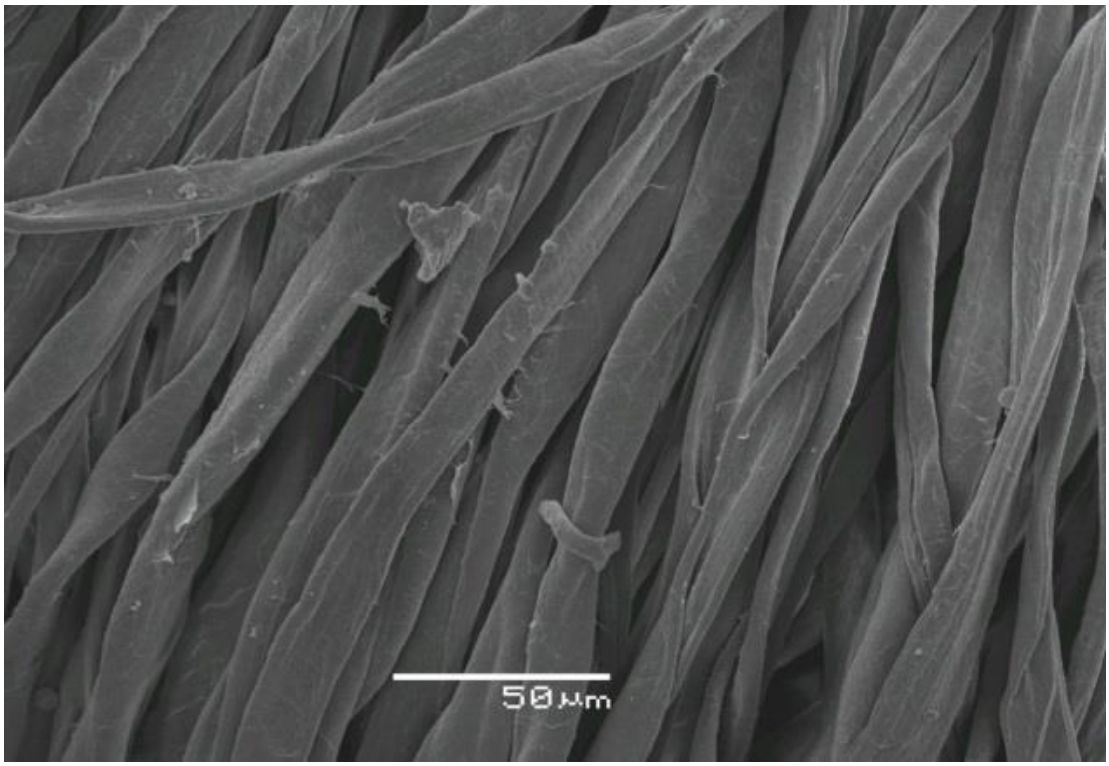


Figure 4 EMS of fiber surface of cotton textile washed with sequestering agent no.1 (magnification 500x)

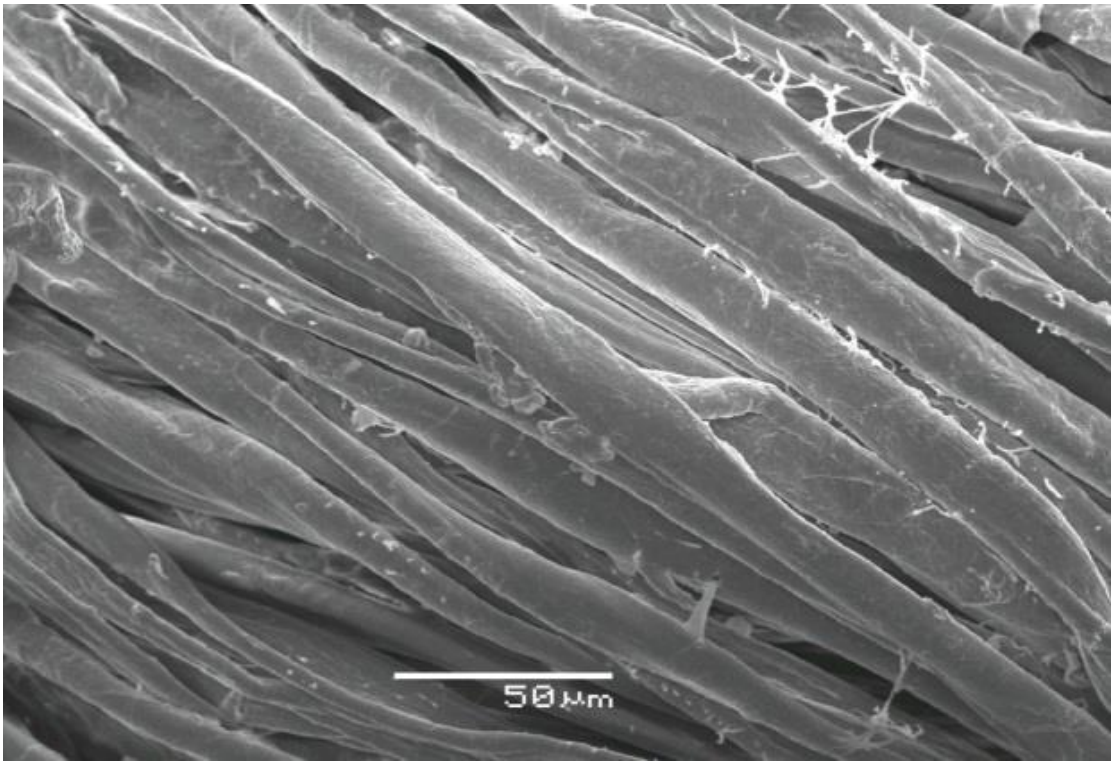


Figure 5 EMS of fiber surface of cotton textile washed with chelating surfactant no.3 (magnification 500x)

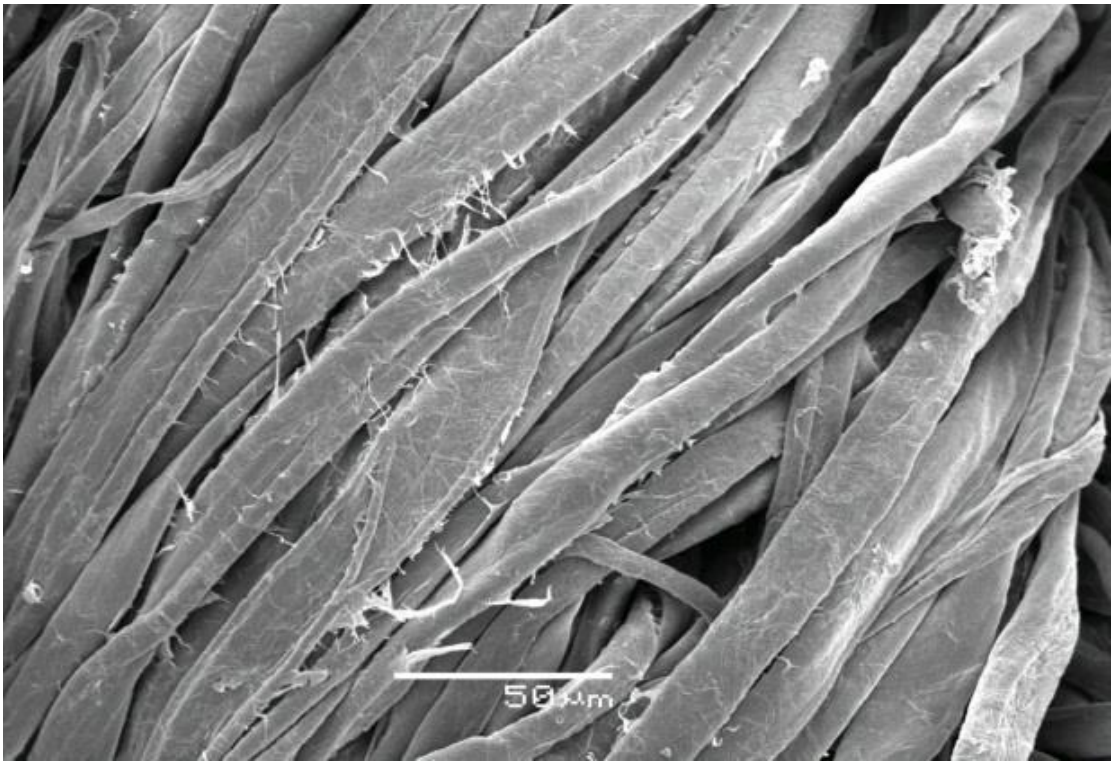


Figure 6 EMS of fiber surface of cotton textile washed with chelating surfactant no.4 (magnification 500x)

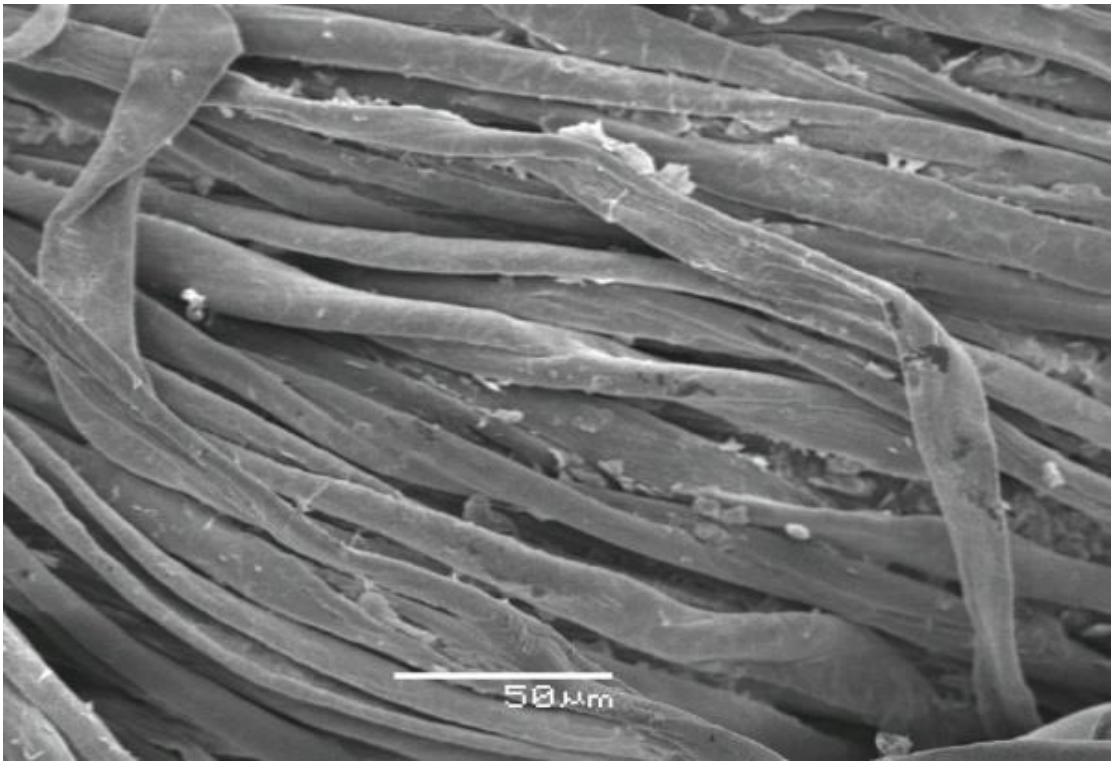


Figure 7 EMS of fiber surface of cotton textile washed with combination no.4 + no.1 (magnification 500x)

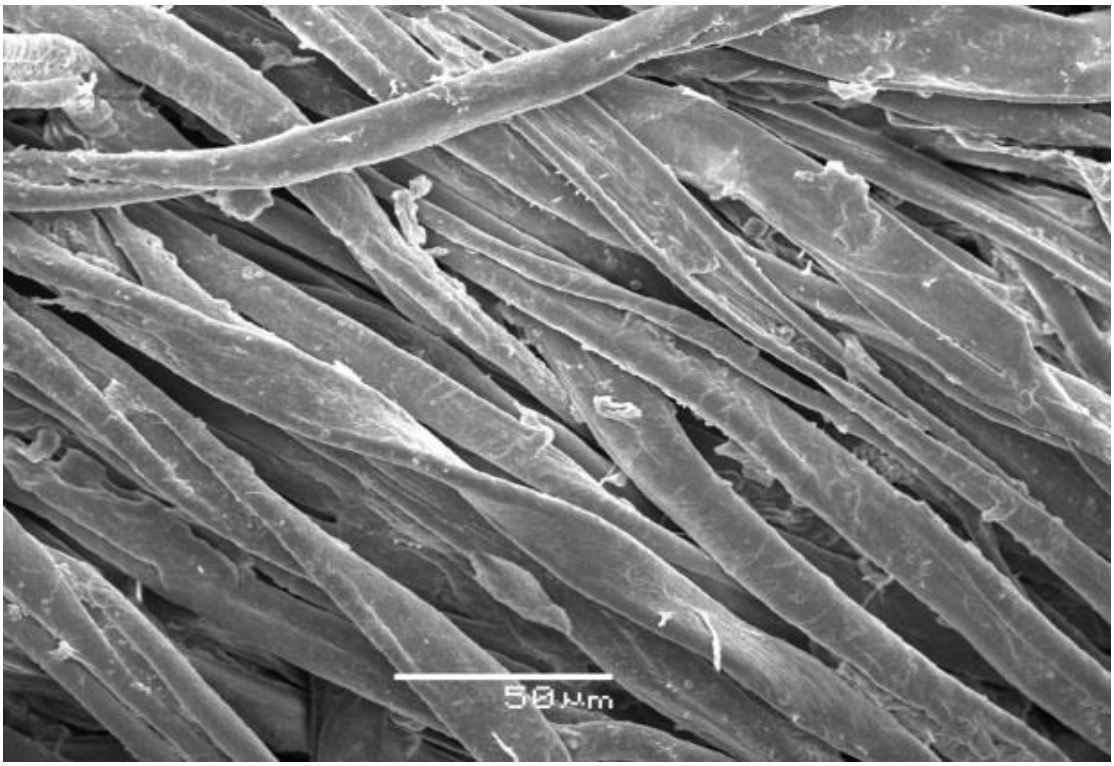


Figure 8 EMS of fiber surface of cotton textile washed with combination no.4 + no.2 (magnification 500x)

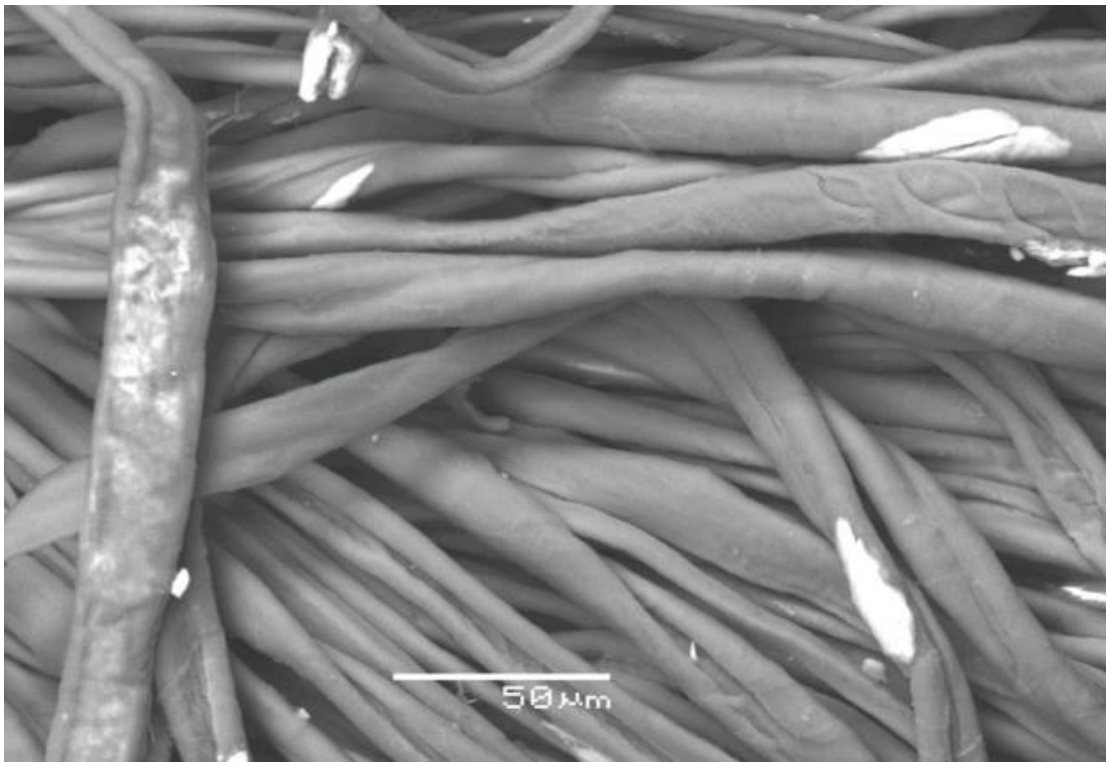


Figure 9 EMS of fiber surface of cotton textile washed with commercial agent I (magnification 500x)

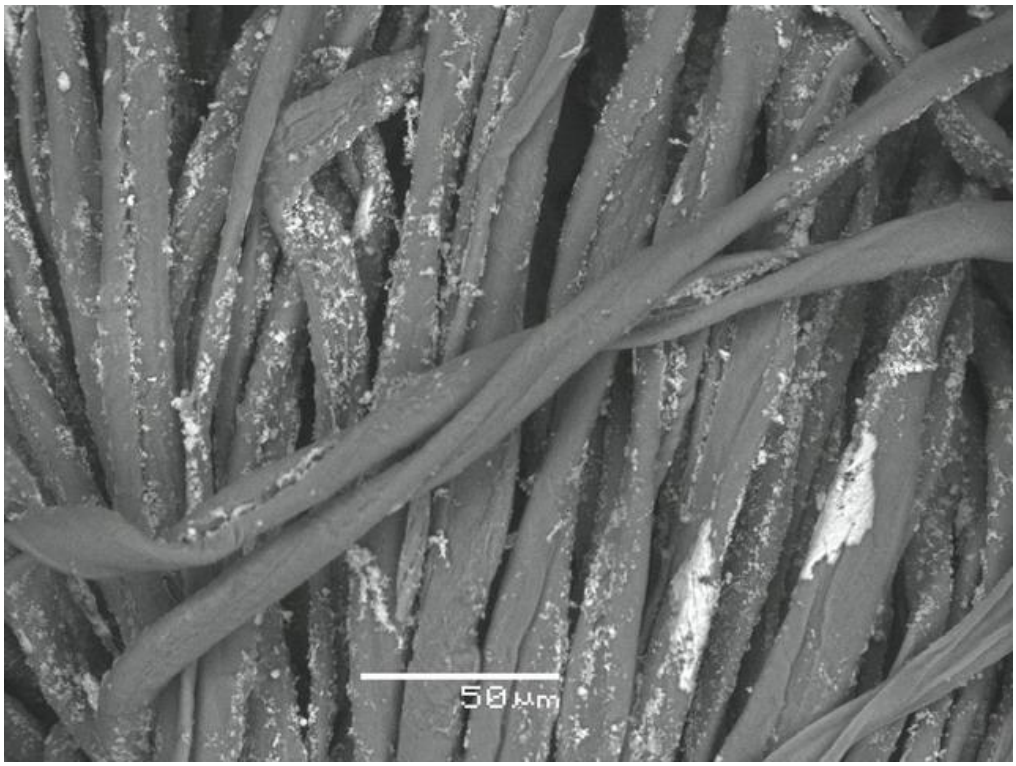


Figure 10 EMS of fiber surface of cotton textile washed with commercial agent II (magnification 500x)

4 CONCLUSIONS

Results of repeated model washing with addition of prepared samples of sequestering agents and chelating surfactants were evaluated in this work. These additions of prepared samples function in the bath positively. Content of calcium ion is reduced, the more limited negative effect.
Washing effect of the prepared samples is comparable with commercial detergents, and the results of the determination of values ash and calcium ion are more favourable to prepared sequestering substances. Picture of fiber surface of cotton textile from a scanning electron microscope complement the idea of the sediment for washing material.
It can be concluded that the prepared sequestrate agents are applicable in many detergent formulas and as the textile auxiliary agents for some finishing operations. Samples no.1 could be recommended as a replacement for existing sequestering agents. Sample no.3 would be suitable as chelating surfactant.

5 REFERENCES

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