Study of the effect of synthesis conditions on the structural properties of biomimetic polysaccharide-templated mesoporous silica

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INTRODUCTION

Research in the field of Biomimetics is one of the most promising today — new materials find their application in medicine, chemistry, pharmacology, physics and instrumentation.

The aim of our work was to obtain a material for selective sorption of bioactive substances using polysaccharide template, as well as to study the influence of synthesis parameters on the characteristics of the synthesized material.

MATERIALS AND METHODS

Mesoporous silica nanoparticles (ZChM-series) have been synthesized via a surfactant-templated sol-gel route using using tetraethoxysilane (TEOS) as the SiO_2 precursor and chitosan as a directing agent and investigated by different physicochemical methods, such as:

- TEM, XRD, Infrared Spectroscopy, UV-Vis spectroscopy (Voronezh State University, Russia)
- BET, TGA (Carl von Ossietzky University of Oldenburg, Germany)

Both acidic and slightly alkaline synthesis conditions were tested. In the acidic method, we varied the molecular weight of chitosan (200 and 500 Da) and the time of TEOS addition.

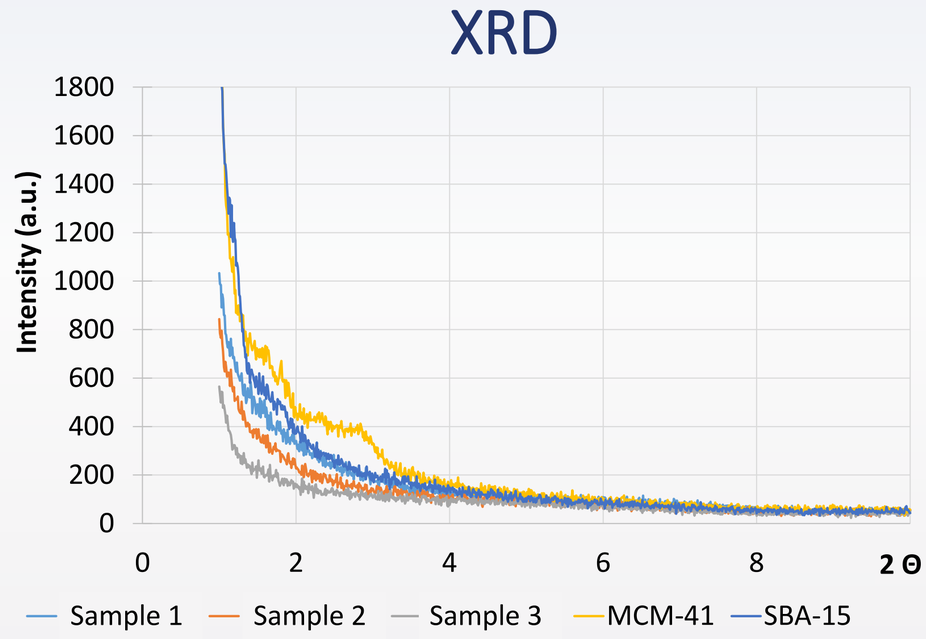
The synthesis parameters are summarized in the table below:

pH	Acidic	Alkaline
Template type	Chitosan molecules (200-500Da)	Chitosan flakes
Temperature	40^0C	25^0C
Time	5-30 min/ 24 h	100 h
Heating	100^0C 24 h	-
Annealing	600^0C 5 h	600^0C 5 h
Naming	ZChM-1a	ZChM-1s

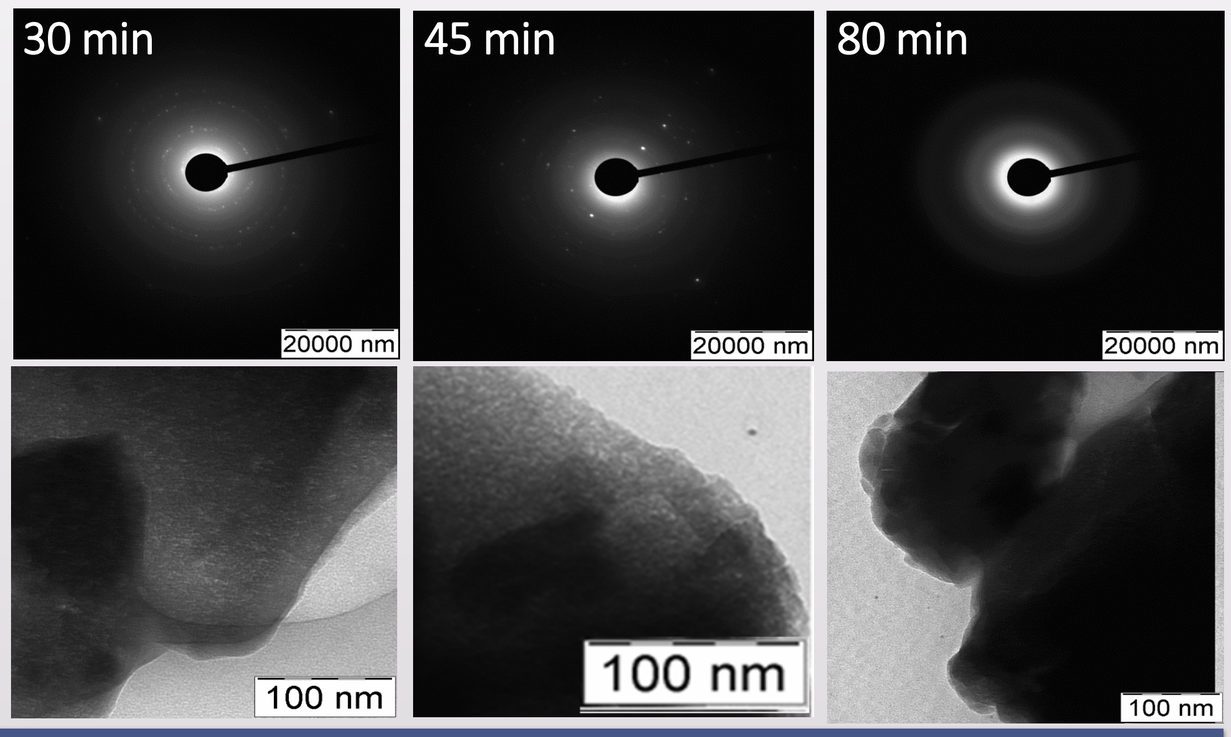
RESULTS & DISCUSSION

According to the obtained data, a material with a more ordered structure was achieved by using an acidic type of synthesis with chitosan 200Da and a controlled rate of TEOS addition. This material has a surface area of around 790 m2/g, which is only is 30% less than the surface area of MCM-41-type materials.

The material synthesized in alkaline conditions has a significantly lower specific surface area. In addition to the surface area, the synthesis conditions also affected the pore size of the resulting materials — the material obtained under alkaline conditions has the largest pore diameter (6,64 nm), while the second sample synthesized in an acidic environment (ZChM-2a) has a slightly lower pore diameter than MCM-41, 2.73 vs. 3.3 nm, respectively. The biomimetic silica synthesized in an acidic medium (ZChM-1a) can sorb tryptophan and phenylalanine. Otherwise, material ZChM-1s (synthesized in an alkaline medium) does not practically sorb these amino acids.



Spatial characteristics of the synthesized material depending on the rate of TEOS addition (acidic method)



CONCLUSION

Thus, chitosan can be successfully used as a template for the synthesis of mesoporous silica. By varying the medium conditions, the molecular weight of chitosan, and the rate of addition of TEOS, it is possible to obtain mesoporous materials with different surface and adsorption properties.