The influence of fucoidan on stability of the TiO_2 suspensions

Jakub Matusiak [1*], Elżbieta Grządka[1], Anna Bastrzyk[2]

[1]Department of Radiochemistry and Environmental Chemistry, Institute of Chemical Sciences, Faculty of Chemistry, Maria Curie-Sklodowska University in Lublin, Maria Curie-Sklodowska Sq. 3, 20-031 Lublin, Poland

[2] Department of Process Engineering and Technology of Polymer and Carbon Materials, Faculty of Chemistry, Wroclaw University of Science and Technology, Wybrzeze Wyspianskiego 27, 50-370 Wrocław, Poland

***Corresponding author: jakub.matusiak@poczta.umcs.lublin.pl**

Introduction

Stability of colloidal systems is very important scientific objective because of the wide range of applications of such systems in science and industry. However, the colloidal systems composed of solid phase dispersed in a liquid medium are rather unstable. To avoid it, the addition of different substances is used to prevent the destabilization of such systems. Nowadays, among others, macromolecular compounds are used as stabilizers. However, the use of synthetic polymers in areas such as pharmaceutical, cosmetic and food industry is limited due to the adverse effect on human health. Therefore, it is important to find natural substitutes for synthetic stabilizers.

Objective

The main objective of this work is to investigate stabilizing properties of the natural polysaccharide – fucoidan – for titanium(IV) oxide suspensions. Fucoidan was chosen because of its bioactive properties and proven positive impact on human health. Moreover, those two substrates can be successfully used in new cosmetic and pharmaceutical formulations.

Fucoidan is a natural sulfated anionic polysaccharide present in different species of brown seaweeds. The basic structure of fucoidan is composed of sulfated fucose backbone, however, it can contain other sugars such as galactose, uronic acid and xylose. Fucoidan is a highly bioactive substance with potentially positive health effects such as anticancer, anticoagulant and antithrombotic, antivirus, anti-tumor and immunomodulatory activities. What is particularly important for skin care products is that fucoidan has also the antioxidant and anti-inflammatory properties [1].

Materials and methods

Fucoidan (*Fucus serratus*) sulfated L-fucose algal polysaccharide was obtained from Carbosynth Limited (CAS No 9072-19-9). Its chemical formula is $(C_6H_9O_3SO_3)_n$. The molecular weight of this polymer estimated using the static light scattering method (SLS, Zetasizer ZS90 Malvern) equalled 1730 kDa. The content of sulfate groups in the fucoidan was estimated by means of the barium sulfate precipitation method and equalled 5.96 %. Anatase-TiO_2 was used as the adsorbent (NanoArc™, AlfaAesar/ThermoFisher Scientific). The specific surface area of this oxide estimated by the low temperature sorption of nitrogen (ASAP BET) equalled 50.3 m^2/g. The average size of the oxide particles equalled 113.6 nm (Zetasizer ZS90, Malvern).

The comprehensive research was carried out including the adsorption (UV-Vis) and stability (turbidimetry) studies. To quantify the adsorption of fucoidan on the oxide surface the colorimetric method proposed by Albalasmeh et al. was used [2]. Stability of the prepared suspensions was measured using the TurbiscanLab Expert (Formulation). The TSI (turbiscan stability index) was calculated using the TurbiSoft Lab software. The TSI parameter values change from 0 (for very stable systems) to 100 (in the case of unstable systems).

Results

The obtained results indicate that the addition of fucoidan influences the stability of TiO_2 suspensions. Conducted adsorption measurements show that the polymer adsorbs on the solid surface (Fig. 1). Stability can be described by the TSI parameter: the lower the TSI, the more stable the studied system is. It can be observed that the pure TiO_2 suspensions are not stable (Fig. 2), because the TSI changes from ~65 to ~95 (in the 1st and the 15th hour). However, when fucoidan is added to the system, stability increases and that the final effect depends on the concentration. Since the polymer adsorbs on the solid surface, the observed stability increase is caused by the electrosteric mechanism [3]. The increase of stability is caused by higher repulsion between the TiO_2 particles covered with fucoidan in comparison to the bare ones.

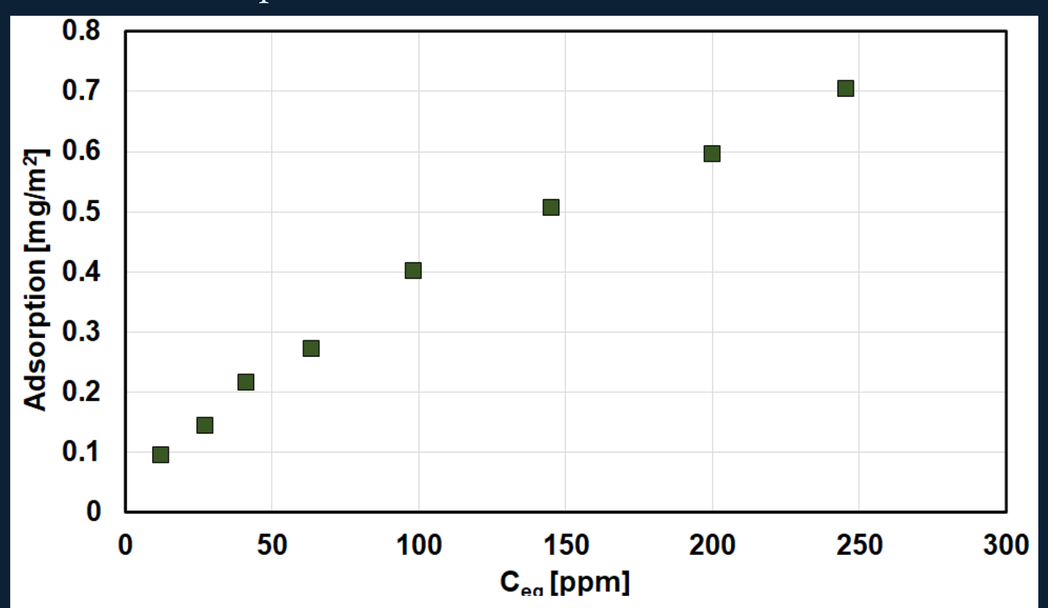

Fig. 1. The adsorption of fucoidan on the TiO_2 surface; 0.01 mol/dm^3 NaCl, pH=7.

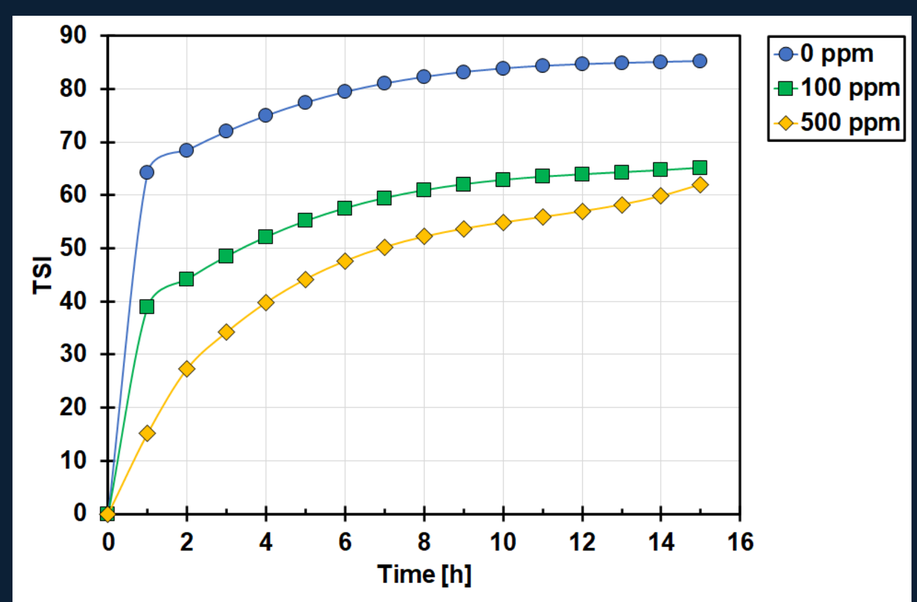

Fig. 2. The influence of fucoidan concentration on stability of the TiO_2 suspensions; 0.01 mol/dm^3 NaCl, pH=7.

Conclusions

- Pure TiO_2 suspensions are not stable
- The addition of fucoidan influences stability of the studied systems
- Stability of the studied fucoidan/TiO_2 suspensions increases with the polymer concentration
- The mechanism responsible for this situation is the electrosteric stabilization
- The conducted studies shine a light on the new possible use of fucoidan in colloidal systems, for example in different emulsions, creams and ointments.

References

[1] Matusiak et al., 2020, Carbohydrate Polymers 245, 116523.
[2] Albalasmeh et al., 2013, Carbohydrate Polymers 97, 253-261.
[3] Matusiak et al., 2018, Colloids and Surfaces A 554, 245-252.

Acknowledgements

The authors would like to acknowledge the National Science Centre, Poland for funding this project (ID 2017/27/N/ST4/02259).

NATIONAL SCIENCE CENTRE POLAND