

MODIFICATION OF CLAY MINERALS TOWARDS ANTIMICROBIAL APPLICATIONS

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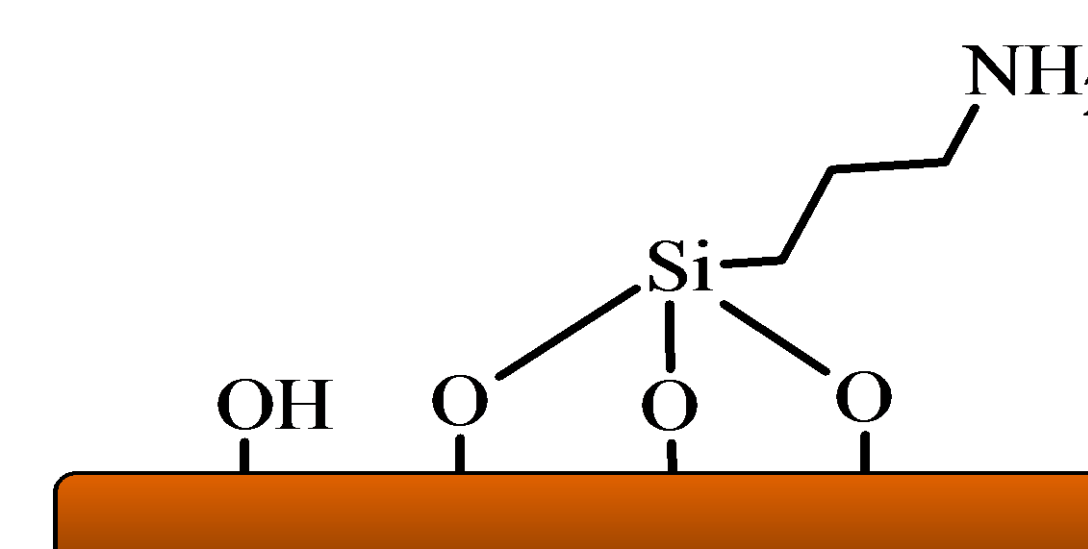
Introduction

Clays or clay minerals is wide group of materials which differ either by their origin or by their exact chemical structure. Properties that all of clays have in common are particle size under 4 micrometers and layered structure of particles. For example montmorillonite is an aluminosilicate which is created by volcanic rock alternation. Its structure consists of layers of tetra and octahedrons and between these layers are hydrated cations which compensate the negative charge of the matrix itself. These cations are exchangeable so it is possible to use this property for chemical modification. [1]

Basic principles

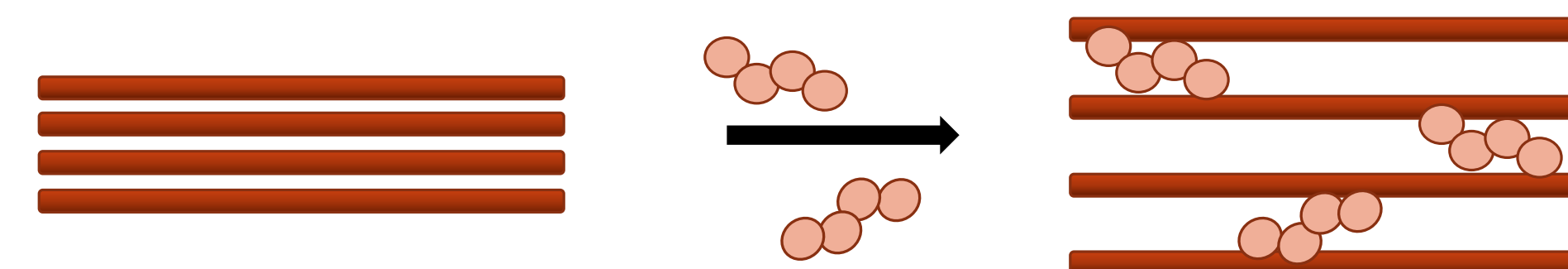
Surface modification

The first way how to change properties of clay mineral is to modify outer structure of clay particles. There are accessible –OH groups on the surface which enable grafting suitable molecules on the surface. For example silanization using (3-aminopropyl)triethoxysilane creates surface with amino groups which are more reactive than hydroxyl groups.



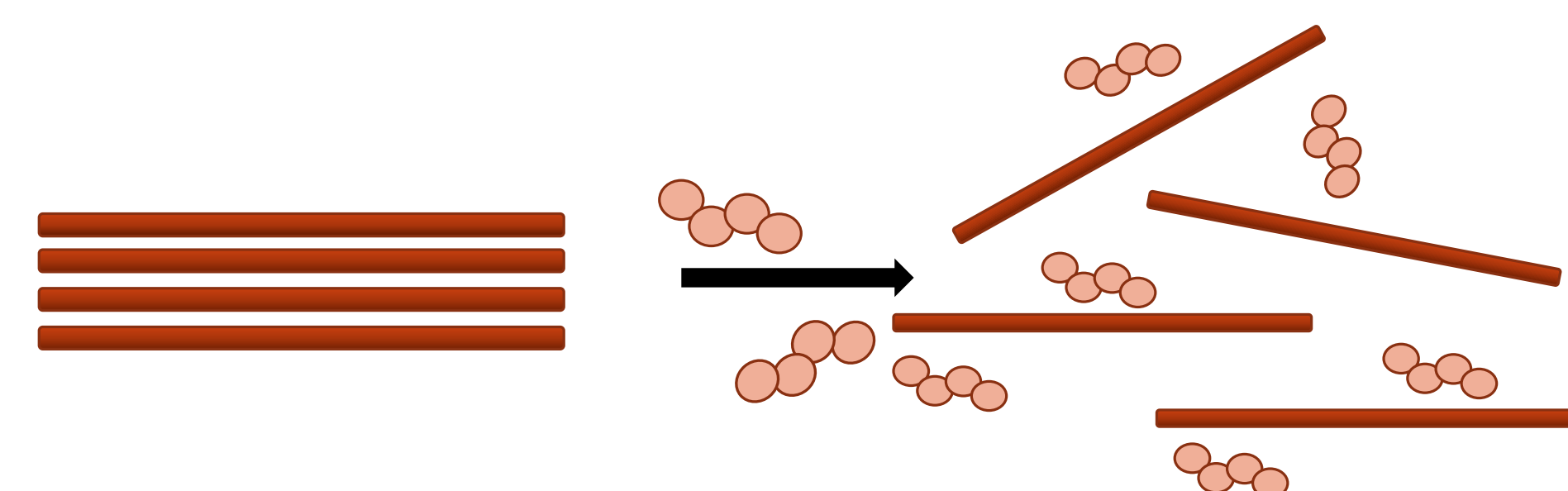
Intercalation

Intercalation is a process when different molecules or ions are inserted into the structure of layered material, more precisely into the space between individual layers. This usually increases the distance between layers, but the particle itself remains compact.



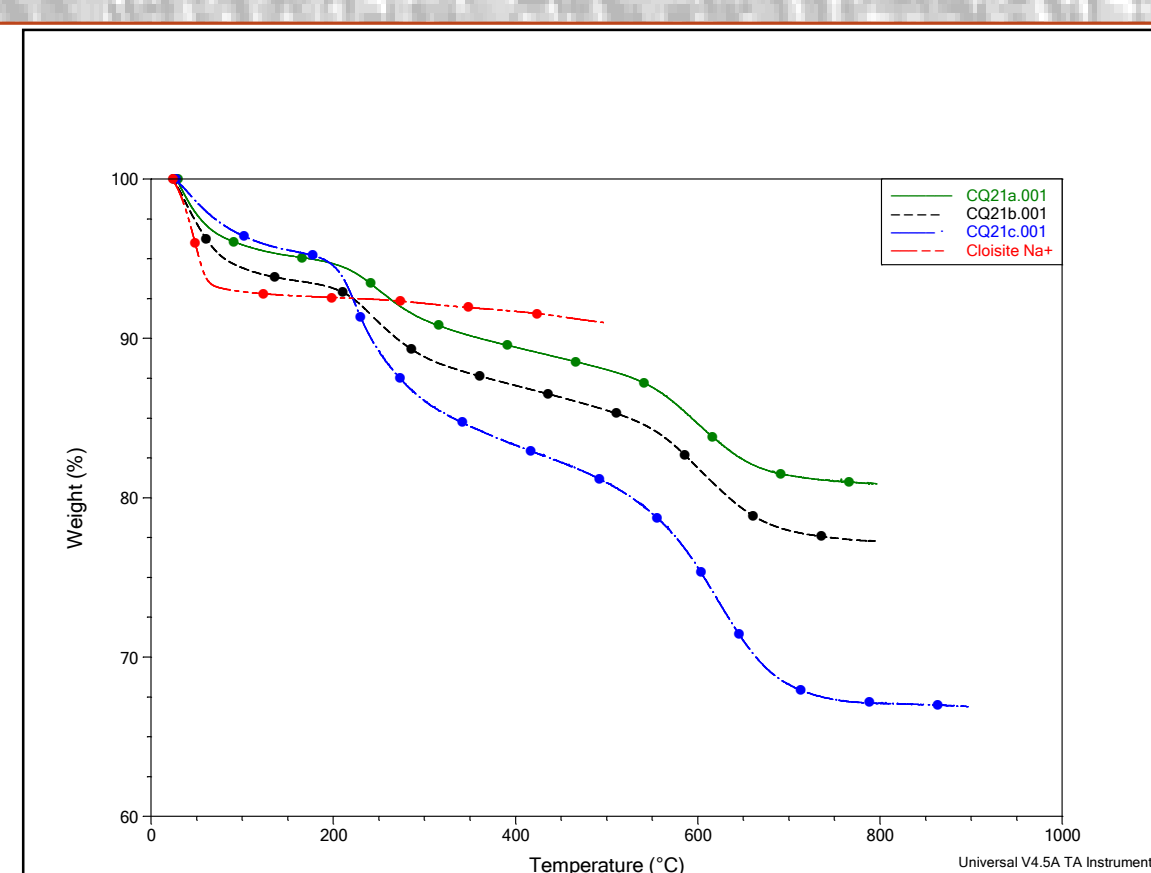
Exfoliation

Exfoliation is a complete disintegration of the particle structure. It is an extreme case of intercalation when inserted molecules cause particle breakdown into individual layers. It is useful when we intend to prepare very thin particles.

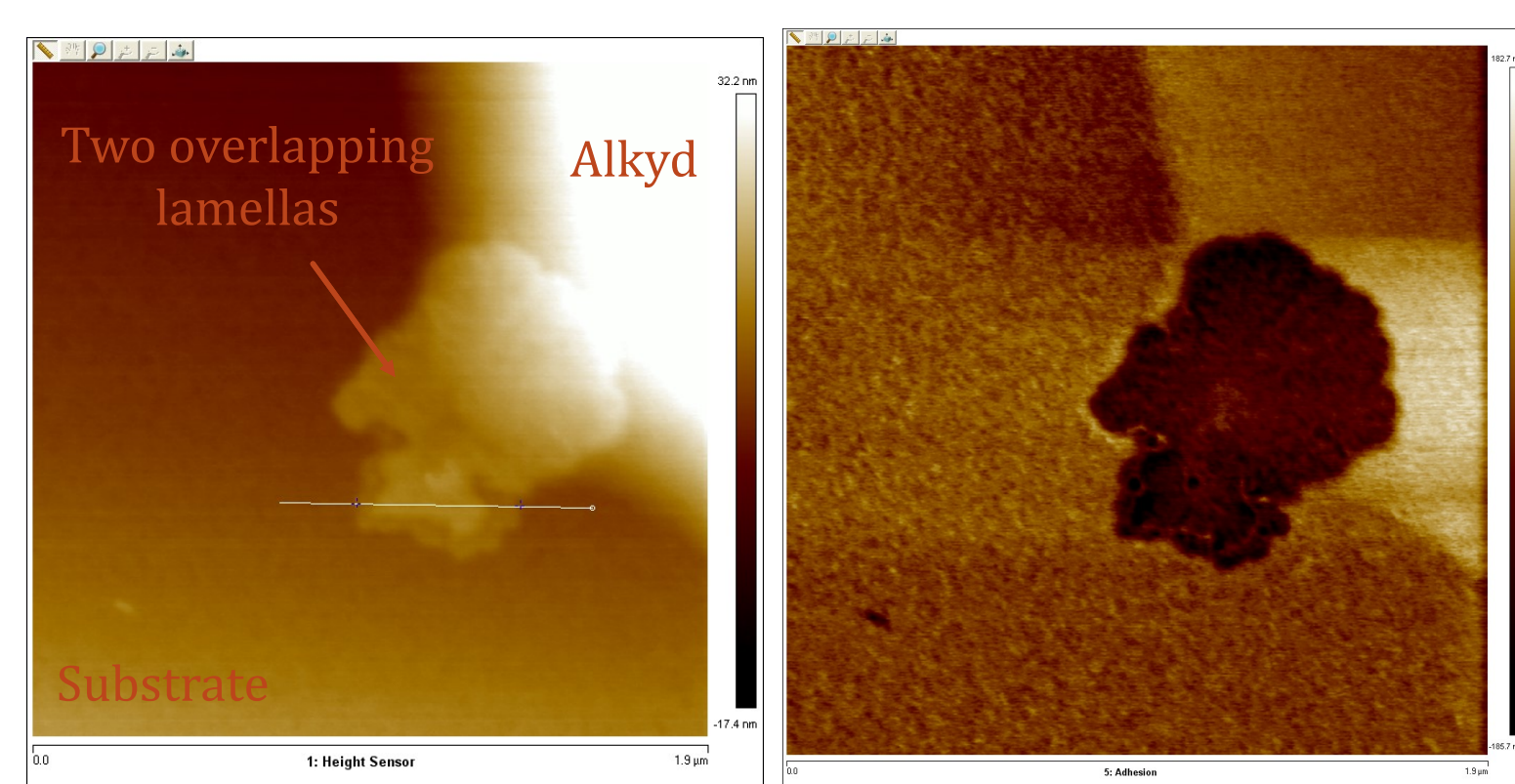


Antimicrobial properties

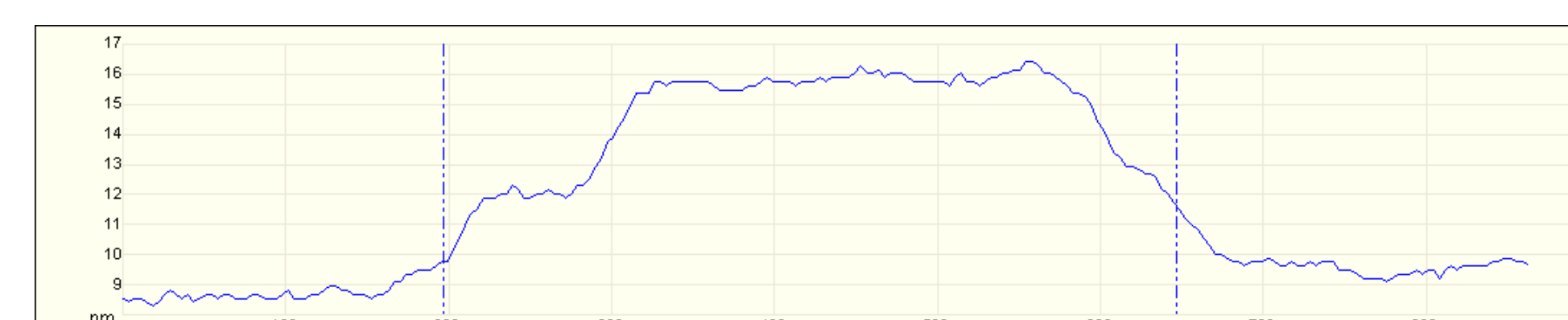
Our approach is to enhance antimicrobial properties of montmorillonite through chemical modification. It has been described in some scientific papers [2], [3] and we try to find new ways and new combinations of reagents to increase efficacy of antimicrobial action. On the other hand, we also modify clay particles to enable their incorporation into various polymer matrices. Mainly we use CloisiteNa⁺ as a basic material which is commercially available montmorillonite with sodium as an exchangeable cation. Our goal is also to create materials which satisfy current trends of sustainable development and green chemistry so we try using natural products (e. g. chitosan) and avoid toxic solvents during the syntheses.



To evaluate the thermal stability of our products we use Thermogravimetric analysis (TGA). It measures decrease of weight of the sample as a function of increasing temperature. In the case of modification with organic molecules this method also enables us to determine the amount of incorporated molecules because the more organic molecules are present the more weight of the sample disappears during the heating. The graph on the left shows results for samples of CloisiteNa⁺ modified with chitosan using various temperature during the reaction (green, black and blue line) in comparison to unmodified clay (red line). The biggest weight loss appeared for sample CQ21c which is montmorillonite modified with chitosan using reaction temperature 60°C, so we assume that this reaction was the most successful.



Atom force microscopy is very powerful technique for studying clay minerals and their incorporation into polymer matrices. Two pictures on the left side show two overlapping lamellas at the interface of alkyd and substrate. First scan is in the topology mode and the second in mode of adhesion. Last picture shows height profile along selected line. It is possible to determine that height of these lamellas is around 3 and 6 nm.



Literature

- [1] BERGAYA et al. *Developments in Clay Science: Handbook of Clay Science*, Volume 1, Pages 1-1224, Elsevier, 2006, ISBN: 978-0-08-044183-2
[2] HAN et al., 2010. Preparation and characterization of chitosan–clay nanocomposites with antimicrobial activity. *Journal of Physics and Chemistry of Solids* 71, 464–467. doi:10.1016/j.jpcs.2009.12.012
[3] WANG et al., 2005. Biopolymer chitosan/montmorillonite nanocomposites: Preparation and characterization. *Polymer Degradation and Stability* 90, 123–131. doi:10.1016/j.polymdegradstab.2005.03.001