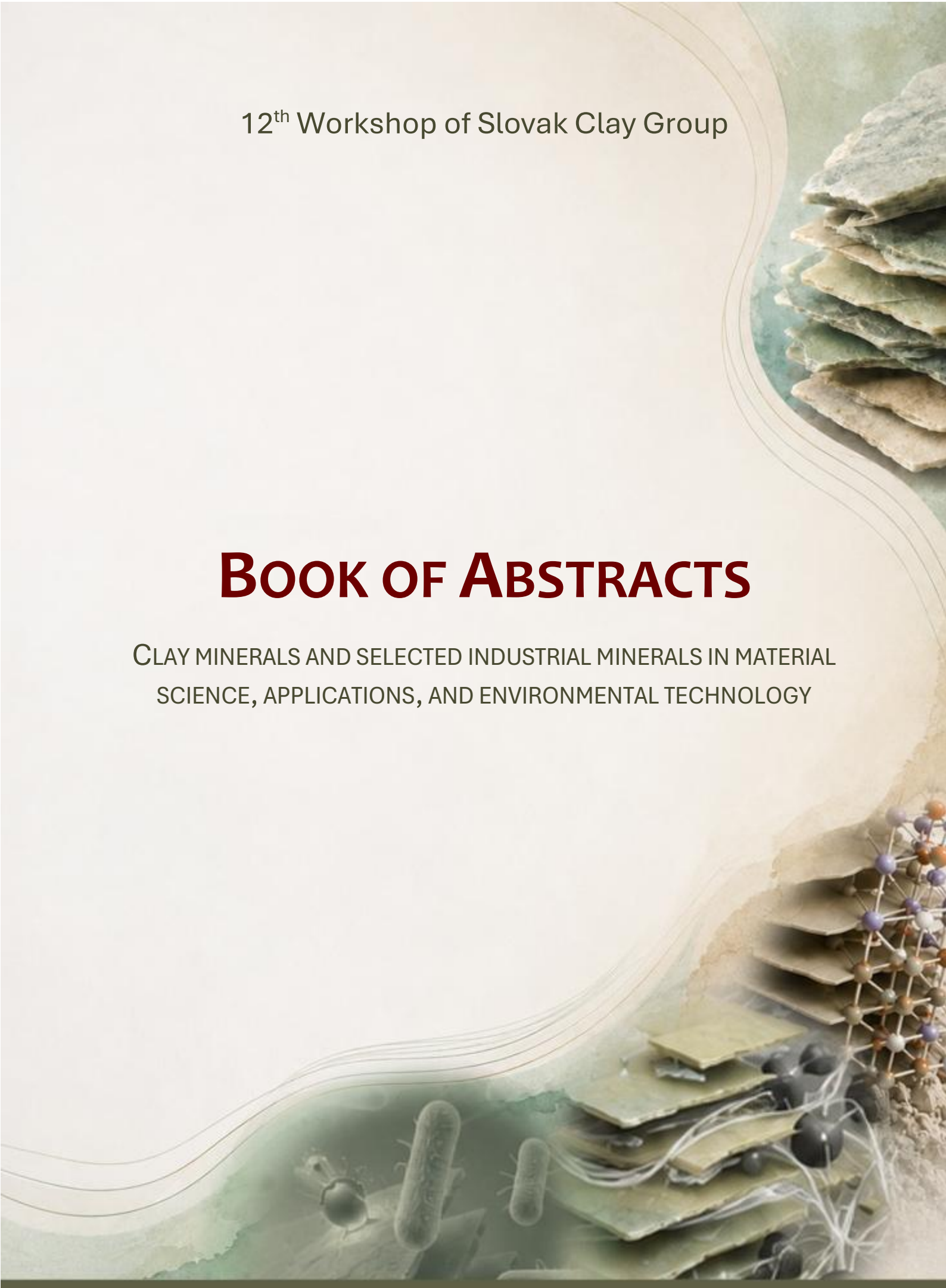
12th Workshop of Slovak Clay Group

Book of Abstracts

Clay minerals and selected industrial minerals in material science, applications, and environmental technology



June 8 – 10, 2026, Vršatské Podhradie, Slovakia

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CONTENTS

Oral Presentations

PROBING TOLUENE ADSORPTION ON MONTMORILLONITE AND SAPONITE: COMPARATIVE COMPUTATIONAL INSIGHTS FROM DFT-D3 METHOD

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KEYWORDS: Montmorillonite | Saponite | Adsorption | Toluene | DFT

One of the most serious environmental issues of the modern period is the contamination of soil and groundwater by volatile organic compounds (VOCs), necessitating the immediate development of effective and long-lasting remediation techniques [1]. Because of its neurotoxicity and environmental persistence, toluene is a typical aromatic volatile organic compound (VOC) that is frequently emitted through industrial processes, fuel combustion, and solvent use, poses major threats to human health and ecological systems. Because of their abundance, affordability, chemical stability, and intrinsic structural properties, natural clay minerals have long been considered appealing options for the removal of pollutants [2].

In this study, we used the Density Functional Theory method with the D3 scheme for corrections of dispersion forces (DFT-D3) to present a thorough computational investigation of toluene adsorption on montmorillonite (Mnt) and saponite (Sap) smectite surfaces [3]. At the molecular level, the adsorption energetics, structural configurations, and host-guest interaction processes of toluene on both clay surfaces were investigated. According to the computed intercalation energies, saponite has much stronger interactions with toluene (ΔE_{int} = –61.3 kJ/mol) than montmorillonite (ΔE_{int} = –47.8 kJ/mol), indicating that saponite performs better at adsorbing toluene molecules.

These results demonstrate that saponite's superior toluene absorption over montmorillonite is due to its unique structural and electrical properties. However, this research provides important theoretical evidence and molecular-level insights into the logical design and selection of natural clay-based adsorbents for efficient VOC remediation in environmental applications.

Acknowledgments:

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ANTI-BIOFILM PHOTODYNAMIC INACTIVATION OF STAPHYLOCOCCUS AUREUS USING AN EOSIN Y NANOCOMPOSITE

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KEYWORDS: Eosine Y |*S. aureus*| Nanocomposite | Photodynamic inactivation

Xanthene dye eosin Y (EosY) is potent photosensitizer (PS) that has attracted attention for its promising antibacterial properties against *Staphylococcus aureus* and their biofilms. The aim was to analyze the photoactive properties of EosY and to demonstrate the effectiveness of polyurethane (PU) - based antimicrobial materials with a nanocomposite film based on saponite modified with poly(diallyldimethylammonium) cations and functionalized with EosY.

Preliminary experiments were performed with the standard strain *S. aureus* CCM 3953. Different concentrations of EosY (from 0.1 µM to 0.1 mM) were tested on planktonic cells. The samples were irradiated with a green laser (λ = 532 nm, 100 mW,) and with green LED light (2.42 mW cm^{-2}). The results were evaluated by calculating the colony-forming units (CFU/mL). The main experiment was conducted with a nanocomposite containing the PS EosY.

EosY at a concentration of 0.05 mM showed inhibitory effect on the growth of planktonic cells, reducing their survival approximately by 10-fold, using both green LED light (1.5 h) and green laser (10 min) compared to control samples representing the growth of bacteria without EosY. PU modified with EosY -functionalized hybrid film achieved approximately 10-fold reduction in biofilm growth of the standard strain of *S. aureus*. To improve the antibiofilm efficacy, the testing was continued using green LED light while varying the light intensities. The results demonstrated that high light intensity caused rapid photodegradation of the dye, accompanied by low efficacy against biofilm. In contrast, at lower irradiation intensities, dye degradation was practically negligible, however, the inhibitory effect remained low and was significantly less than a 10-fold reduction, even after irradiation following 24 and 48 h. The highest anti-biofilm effect (more than a 100-fold reduction) was achieved during irradiation for 1.5 h at a green LED light with intensity of 25%, and under these conditions, only minimal degradation of the dye in the nanocomposite was visually observed.

In summary, the results showed that the nanocomposite functionalized with the photoactive molecule EosY exhibited a pronounced inhibitory effect against *S. aureus*, which was significantly enhanced by adjusting the irradiation conditions. These results highlight the crucial role of irradiation parameters, the optimization of which can significantly improve the overall anti-biofilm efficacy of the nanocomposite.

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ADSORPTION IN CLAY COLLOIDAL SYSTEMS: A SIMPLE OR A COMPLEX PHENOMENON?

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KEYWORDS: Colloidal systems | Organic dyes | Diffusion | Molecular aggregation | Smectites

Adsorption in aqueous colloidal systems describes the change in local concentration of molecules at the surface of an adsorbent, as solvent molecules (typically water) are replaced by adsorbate molecules. Simple models, originally developed for adsorption from the gas phase, are often used to describe this process. However, the role of water molecules, their interactions with the adsorbate and the adsorbent surface, and especially hydrogen bonding between them, is frequently neglected. As a result, the mechanisms proposed by such models often fail to reflect the true nature of the processes and may lead to misinterpretation of the applicability of a given system [1,2].

This presentation will outline the basic principles of dye molecule adsorption on smectite surfaces [3], which can also be extended to organic molecules in general. As an illustrative example, a model system of rhodamine dye molecular aggregation will be discussed [4]. It will show how diffusion processes govern adsorption and the distribution of molecules on the adsorbent surface. The complexity of the phenomenon is further enhanced by additional effects, such as destabilization of colloidal systems following adsorption of organic molecules, which in turn influence individual diffusion processes and, in particular, the reaction kinetics [5].

Before concluding, a summary of the fundamental concepts of adsorption in these systems will be presented. Finally, the lecture will provide connections to basic thermodynamic principles and mechanistic analyses, offering insights applicable to similar systems.

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PHOTOACTIVE SMECTITE HYBRID MATERIALS FOR SINGLET OXYGEN GENERATION: PREPARATION, PROPERTIES AND APPLICATIONS

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KEYWORDS: ROS| Photosensitisers | Layered silicates | Photophysical properties

Singlet oxygen ($^1O_2$) is an electronically excited form of molecular oxygen characterized by paired electron spins and high chemical reactivity. Unlike ground-state triplet oxygen, many of its reactions are spin-allowed, making singlet oxygen a powerful oxidizing agent. Owing to these properties, $^1O_2$ has found applications in advanced oxidation processes for environmental remediation, photochemical synthesis, photodynamic therapy, and the development of antimicrobial materials.

Since molecular oxygen exhibits only weak absorption in the UV–Vis spectral region, singlet oxygen is commonly generated through photosensitization. In this process, a photosensitizer absorbs light and transfers its excitation energy to molecular oxygen. However, the practical application of photosensitizers is often limited by molecular aggregation, self-quenching processes, and enhanced non-radiative deactivation pathways, which reduce their photoactivity and singlet oxygen production efficiency.

Layered silicates, particularly smectites, provide an attractive platform for overcoming these limitations. Adsorption of photoactive molecules on clay surfaces can suppress aggregation, modify molecular organization, and improve the stability and photophysical properties of the photosensitizers. As a result, smectite-based hybrid materials have emerged as promising systems for efficient singlet oxygen generation.

This contribution presents an overview of photoactive smectite hybrid materials designed for singlet oxygen production, focusing on their preparation, photophysical properties, and selected applications in environmental and biomedical fields.

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SURFACE AND STRUCTURAL CHARACTERISATIONS OF PVA/GLYCEROL HYDROGELS FEATURING PHLOXINE B-SAPONITE COMPOSITE SURFACE LAYERS

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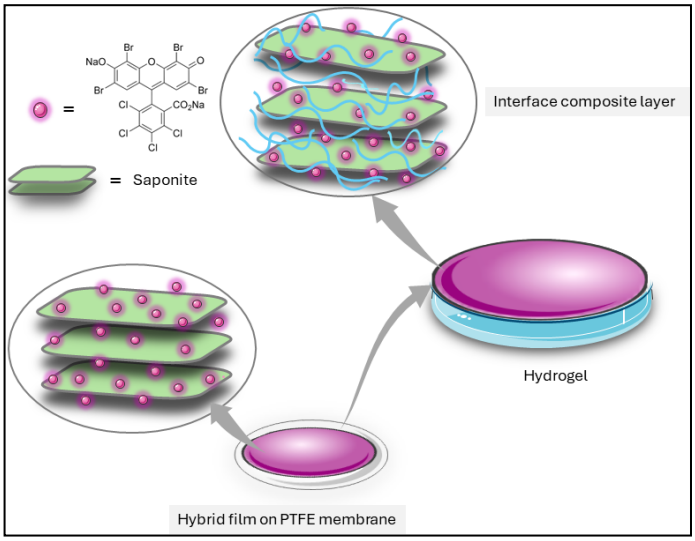
KEYWORDS: Smectite | Thin film | Hydrogel nanocomposite | Photosensitizer

A photosensitizer (PS), phloxine B (PhB) functionalized thin film of organically modified saponite, prepared via vacuum filtration, was attached to the surface of polyvinyl alcohol/glycerol hydrogel during the crosslinking process. This film formed a composite interface layer that imparts photophysical and photodynamic inactivation properties to the hydrogel [1]. The structural and surface characteristics of the composite layer were evaluated using Fourier-transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), energy-dispersive X-ray spectroscopy (EDS), and water contact angle measurements. FTIR analysis demonstrated the progressive formation of a more hydrophobic organoclay and the incremental incorporation of PhB into the films. The absence of significant changes in the characteristic peaks of the constituents indicates no chemical alteration during film formation. However, the FTIR signals of the composite layer obscure those of other components. XPS elemental analysis confirmed the presence of functional molecules at the gel surface, supporting its suitability for intended applications. Water contact angle measurements revealed that the composite layer is highly hydrophilic, which may inhibit direct hydrophobic adhesion of bacterial cells. The combined structural, elemental, and wettability analyses confirm the formation of a composite layer on the hydrogel surface that retains the characteristic structural features and elemental composition of the constituent materials.



Acknowledgment:

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INTERACTION OF SYBR GREEN I WITH SAPONITE INVESTIGATED BY FLUORESCENCE SPECTROSCOPY AND COMPUTATIONAL METHODS

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KEYWORDS: SYBR Green I | Saponite | Fluorescence spectroscopy | DFT calculations

The interaction of the fluorescent nucleic acid dye SYBR Green I with saponite dispersions was investigated using excitation–emission matrix (EEM) fluorescence spectroscopy and computational modelling [1]. SYBR Green I was mixed with aqueous saponite dispersions (0.125 g L^{-1}) at dye loadings ranging from 0.005 to 0.08 mmol g^{-1}. Fluorescence measurements were performed immediately after sample preparation, after one hour, and after one week to evaluate time-dependent changes in fluorescence behavior [2]. A significant increase in fluorescence intensity was observed after interaction with saponite, indicating adsorption of the dye onto the clay surface and suppression of non-radiative relaxation processes. The results suggest gradual stabilization and reorganization of dye molecules within the clay environment, with fluorescence behavior depending on dye loading [3]. To gain molecular-level insight into the observed behavior, molecular dynamics (MD) and density functional theory (DFT) calculations were performed for SYBR Green I in different environments. The combined experimental and computational approach contributes to a better understanding of hybrid dye–clay systems and their photophysical properties.

Acknowledgment:

This work was supported by the Slovak Research and Development Agency under the contract no. APVV-21-0302 and APVV-22-0150.

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SHUNGITE AS A PROMISING MINERAL-BASED MATERIAL FOR ENGINEERING APPLICATIONS

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KEYWORDS: Shungite | Mineral-based materials| Contaminated water treatment| Geopolymer composites

Shungite is a carbon-containing mineral material of volcanic-sedimentary origin, composed mainly of silicon dioxide, aluminium oxide and carbon, with variable amounts of iron, calcium and other minor components depending on its type and origin. Due to its specific mineralogical and carbonaceous composition, shungite has attracted attention as a potentially useful mineral-based material for engineering applications, particularly in relation to pollutant removal and shielding properties. Fullerene-like carbon structures have also been reported in shungite, although their occurrence and role in the material properties require further investigation [1].

In preliminary experiments, shungite was tested for the purification of river water affected by mine wastewater containing copper, zinc and cadmium using filter dam systems on the Sekisovsk River, Kazakhstan. The results, evaluated by atomic absorption spectrometry, indicated effective removal of metal pollutants from contaminated water, suggesting that this mineral material may have potential for the remediation of environments affected by heavy metals and, potentially, other inorganic and organic pollutants. In parallel, shungite-based geopolymer materials were prepared and their mechanical properties were evaluated. The obtained results showed compressive strength values in the range of 5.5–9 MPa and flexural strength values of 1–1.2 MPa, depending on the composition. Although these materials exhibited relatively high hardness, but their brittle character limits their mechanical performance. Therefore, the incorporation of alkali-resistant glass fibres may represent a promising approach to improve the properties of shungite-based geopolymer composites.

Overall, the combination of pollutant removal potential, shielding properties and geopolymerisation makes shungite a promising mineral-based material for engineering applications. Shungite-based geopolymers could be considered for contaminated water treatment, waste immobilisation, and specialised elements with shielding functions. Further research is required to optimise their composition and evaluate mechanical performance, shielding efficiency and pollutant adsorption capacity.

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TRAPPED AND LETHAL: SAPONITE AS THE ULTIMATE HOST FOR BODIPY DYES

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KEYWORDS: BODIPY | Photochemistry | Hybrid materials | Fluorescent dyes

BODIPY (boron-dipyrromethene) dyes are renowned for their high molar extinction coefficients, narrow emission bands, and exceptional photostability, properties that can be precisely tuned through chemical substitution [1,2].

This study details the design and synthesis of a series of substituted BODIPY fluorophores, tailored for integration into inorganic frameworks. The synthesized substances were rigorously characterized using ^{1}H and ^{13}C NMR spectroscopy to confirm molecular structure, Mass Spectrometry (HRMS) to verify molecular weight, and FTIR spectroscopy to identify characteristic vibrational modes, such as the B-F and C-N stretching frequencies.

To enhance the photophysical stability and processability of these dyes, they were incorporated into saponite, a synthetic layered silicate, forming organic-inorganic hybrid materials as shown in Fig.1.

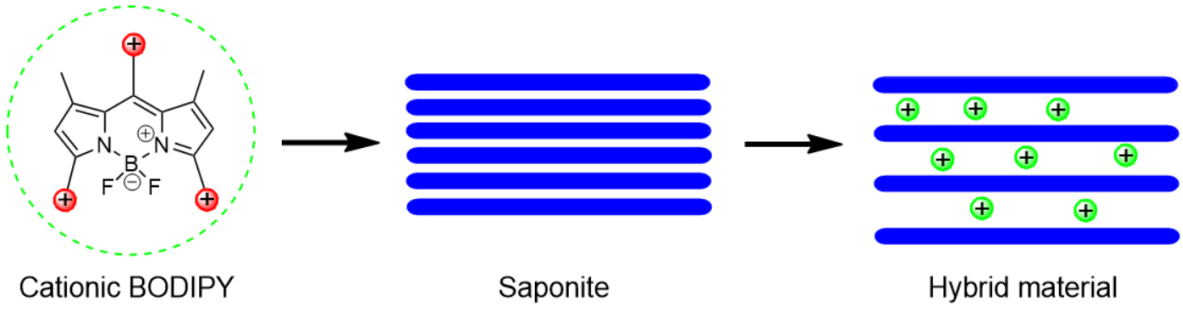

Fig. 1. Representation of the intercalation of organic dyes in saponite forming hybrid materials.

The intercalation and adsorption mechanisms within the saponite layers were investigated to ensure high loading and reduced dye aggregation. Finally, the antibacterial efficacy of BODIPY was evaluated. Results indicate that some of these compounds exhibit significant antibacterial activity, likely driven by the photo-induced generation of reactive oxygen species (ROS), suggesting their potential as components in light-activated coatings for antimicrobial surfaces.

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MONITORING OF INTERPARTICLE DIFFUSION OF DYE CATIONS IN SAPONITE DISPERSIONS BY FLUORESCENCE SPECTROSCOPY

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KEYWORDS: FRET | Smectite | Diffusion | Fluorescence spectroscopy

Interparticle diffusion in colloidal clay systems plays an important role in adsorption and transport phenomena [1,2]. However, direct experimental evidence remains limited. A recent study has shown that dye/clay mineral dispersions exhibit dynamic behavior, including diffusion on the surface and between the particles, repeated desorption and readsorption [3]. In this work, interparticle diffusion of organic dye cations adsorbed on saponite (Sap) particles was investigated using Förster resonance energy transfer (FRET).

Synthetic saponite dispersions containing rhodamine 6G as an energy donor (ED) and oxazine 4 as an energy acceptor (EA) were mixed directly during fluorescence measurements. The ED molecules were selectively excited to measure FRET from ED to EA. The simultaneous decrease in ED fluorescence, in favor of EA emission, confirmed the migration of dye molecules between Sap particles and their interaction within the efficient FRET distance range.

The kinetic profiles revealed a strong temperature dependence of interparticle diffusion. Faster equilibration and more pronounced fluorescence changes were observed at elevated temperatures. The experimental results were compared with a theoretical model based on FRET efficiencies and theoretical statistical distributions of intermolecular distances. Additional effects, including concentration quenching and colloidal destabilization, were identified as factors contributing to the observed fluorescence changes.

The presented results demonstrate that fluorescence spectroscopy combined with FRET provides a sensitive tool for studying nanoscale transport phenomena in hybrid clay colloids. The method provides selectivity for interacting ED/EA pairs and does not disturb the native colloidal environment, making it promising for probing more complex systems relevant to catalysis and environmental chemistry.

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PH-RESPONSIVE ROLLING BEHAVIOR OF SMECTITE-POLYMER COMPOSITES LOADED WITH CURCUMIN

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KEYWORDS: Smectites | Chitosan | Composite | pH-responsive material

Smectites, as materials possessing a negative layer charge, provide an opportunity to intercalate various cationic species such as organic cations, polycations, and biopolymers. The intercalation of stimuli-responsive polymers leads to the design of composite materials that exhibit functional changes upon exposure to specific stimuli such as variation in pH, temperature, light, or magnetic fields [1]. This work focused on optimizing the preparation procedure of composites based on selected smectites and polymers to develop a double-layer film capable of shape changes in response to different pH environments. Furthermore, incorporation of curcumin, as a model drug molecule, in the composite was performed to assess the film's effectiveness as a drug carrier.

The composite film was made of two smectite-polymer layers. Two smectites: trioctahedral synthetic hectorite and dioctahedral montmorillonite were used to prepare composites with chitosan and polyvinyl alcohol (PVA). The film was prepared by casting the smectite-chitosan dispersion onto the fresh smectite-PVA layer formed by a freeze-thaw process, which serves as the substrate. The method ensures the formation of a stable, uniform double-layer film, with each layer serving a distinct purpose. The smectite-PVA layer provides mechanical stability, while the smectite-chitosan layer enhances functionality, particularly pH sensitivity. Hydrogen bonding at the interface between the two layers stabilizes their mutual adhesion, enabling the film to function as a cohesive and unified material. The obtained SEM images of the film confirmed the successful integration of the two layers, showing a continuous stacked morphology in cross-section without significant interfacial defects. To evaluate the pH-responsiveness of the film, pieces of defined diameters were immersed in biological buffer solutions simulating the gastrointestinal and blood media. The films exhibited a rolling behavior, with the direction of rolling depending on the medium in which they were placed. In acidic media (pH 4.5), the smectite-chitosan layer was positioned outward during film rolling, whereas in alkaline media (pH 7.4), the reverse configuration was observed, and the smectite-PVA layer was placed as the outer surface. This shape-altering phenomenon highlighted the intrinsic pH-sensitivity of the system, which originates from the chitosan-containing layer, where protonation in acidic media and deprotonation in alkaline media induce different rolling behaviours in polycation-modified smectite.

Acknowledgment:

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IMPACT OF CLAYS AND ORGANIC MATTER ON THE CONSOLIDATION AND WATER SORPTION/RELEASE FROM THE ALBERTA OIL SANDS TAILINGS

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KEYWORDS: Oil sands | Tailings | Clays

Recently, the dewatering and consolidation of oil sands tailings (OST) is likely the most challenging problem faced by the oil industry. Although clays and residual organics comprising the OST may be largely responsible for slow dewatering and low consolidation rates of OST their particular role is still poorly understood. The main goal of this study was to better understand the effect of clays and residual organics on OST settling behavior and water sorption and release. Removal of residual organics (using solvent and bleach) from OST led to the settling of OST solids to a substantially smaller volume due to the disaggregation of larger organic matter-clay aggregates into smaller particles. The uppermost OST settling layers (finer particles) were enriched in illite, kaolinite, illite-smectite and kaolinite-smectite whereas the bottom OST settling layers (coarser particles) were enriched mainly in quartz, feldspars and often also chlorite. The highest concentrations of interstratified illite-smectite were associated with the smallest and the thinnest OST particles. The water sorption and release in OST settling layers were controlled by illite-smectite content; with increasing amount of illite-smectite the water sorption and water release were higher.

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USE OF GROG IN BRONZE AGE CERAMIC PRODUCTION: THE CASE OF HATVAN CULTURE POTTERY IN SOUTH-CENTRAL SLOVAKIA

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KEYWORDS: Ceramic manufacture traditions | Grog temper | Hatvan culture | Geoarchaeology

This study examines Early Bronze Age Hatvan Culture ceramics from Včelince (south-central Slovakia) using thin-section petrography, SEM–EDS, and electron microprobe analysis (EMPA) to investigate raw material use and manufacturing technology, with particular focus on the recurrent presence of grog temper.

The results indicate a mixed provisioning strategy dominated by local resources with minor regional and non-local components. Grog temper was identified in approximately 50% of the analyzed samples, suggesting intentional technological practice rather than accidental inclusion [1]. Variability in grog composition further reflects flexible paste preparation and limited standardization of ceramic recipes.

The occurrence of grog-tempered fabrics at Včelince corresponds with broader technological traditions documented across the Carpathian Basin [2–4]. Comparisons with other Hatvan assemblages, particularly from Salgótarján–Mt. Pécskő [5], support the interpretation of predominantly local production combined with regionally shared technological traditions. Overall, the preliminary results highlight grog temper as an important technological marker linking the Včelince assemblage to wider Bronze Age ceramic traditions of the Carpathian Basin.

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IMMOBILISATION OF CHROMATE POLLUTANTS BY POLYETHYLENEIMINE-MODIFIED MONTMORILLONITE

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KEYWORDS: Polyethyleneimine | Adsorption | Montmorillonite | AIMD calculation

Oxyanions of heavy metals, such as chromates, can be harmful to humans and animals, even at low concentrations [1]. They can cause health issues including nervous system damage, kidney problems, reproductive disorders, and even cancerous conditions [2]. Additionally, these substances can build up in the environment and damage ecosystems. They can contaminate soil and groundwater, possibly resulting in persistent effects on plants and animals [3].

This research offers a comprehensive investigation into the adsorption of hazardous chromate contaminants within the interlayer region of PEI-modified montmorillonite (Fig. 1), utilising both computational and experimental techniques.

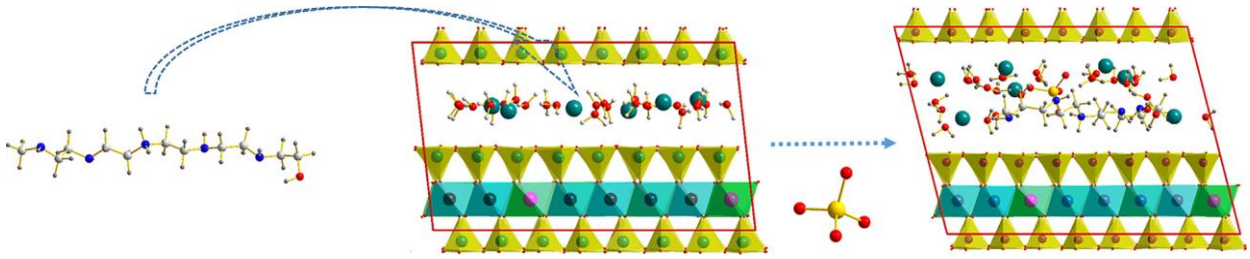

Fig. 1 Modification of Mnt using PEI and adsorption of chromate pollutant.

The primary goal is to conduct thorough structural research, including assessing structural stability and evaluating the strength of hydrogen bond interactions within the studied systems. Additionally, the FTIR spectra were compared with the vibrational modes calculated from the vibrational density of states using the ab initio molecular dynamics (AIMD) method to analyze the overlapping bands of different functional groups in detail.

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Invited lecture

THE STRUCTURAL IMPERFECTIONS IN CO_2 BINDING EFFICIENCY ON HYDROTALCITE-LIKE PRECURSORS AND DERIVED MIXED OXIDE SORBENTS - SPECTROSCOPIC AND THEORETICAL STUDY

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KEYWORDS: Mineral basic solids | In situ FTIR measurments | CO_2 probe molecule | Quantum-chemical modelling of CO_2 interactions

Scientific research shows that nature does not favour perfect solutions at all; on the contrary, surface imperfections are essential for chemical reactions to occur, or nature favours such sites due to energy-related reasons. This study investigates the priority effect in hydrotalcite-like derived precursors and their oxides, in determining CO_2 sorption performance, using in situ FTIR spectroscopy supported by structural characterization and quantum-chemical modeling.

Density functional theory calculations performed for CO_2 adsorption on magnesium oxide surfaces revealed that adsorption on MgO terraces composed of five-coordinated O^{2-} sites is energetically unfavorable. In contrast, low-coordinated sites significantly stabilize CO_2 molecules, forming surface carbonate species. These findings demonstrate that it is structural imperfections, rather than flawless crystallography, govern the effectiveness of CO_2 binding. This “priority effect” highlights the dominant role of accessible defect sites and their strength in CO_2 adsorption on surfaces with heterogeneous basicity.

Guided by these insights, hydrotalcite-like (Htlc) derived precursors were designed by introducing controlled heterogeneity into magnesium-based systems. Double and triple Mg–Al and Mg–Al–Fe Htlc nanostructured components with varying Mg/Al/Fe ratios were synthesized and transformed into mixed oxides. The obtained materials differed in composition, crystallinity, and textural properties, as confirmed by XRD, SEM/EDS, N_2 sorption, and FTIR analyses.

Advanced in situ FTIR methodology with CO_2 as a probe molecule, developed by our team, revealed the formation of carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) species through interactions with surface O^{2-} and OH^- groups of synthesised materials. Quantitative spectroscopic analysis allowed quantitative differentiation between O^{2-} and OH^- centres by analysing CO_2 adsorption products. This methodology, complemented by temperature-programmed CO_2 desorption, indicated the priority in releasing the occupied sites and also revealed that transformation of Mg–Al Htlc into oxides enriched the surface with surface O^{2-} of higher basic strength. Notably, sorption capacity correlated with the intrinsic strength of defect-related basic sites, as well as their accessibility and distribution. Such studies provided unprecedented insight into surface basicity and its role in CO_2 activation mechanisms.

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POSTER PRESENTATIONS

ANTIBACTERIAL ACTIVITY OF PHOTOACTIVE IMPLANTS: FROM IN VITRO TESTING TO IN VIVO MODEL

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KEYWORDS: Nanocomposites | *Galleria mellonella* | *S. aureus* | Photodynamic inactivation

Staphylococcus aureus can form biofilms on the surfaces of medical devices and is responsible for a wide range of implant-associated infections. Biofilm formation significantly complicates the treatment of these infections due to the increased resistance of biofilm-embedded bacteria to antimicrobial agents. Surface modifications of medical devices represent a promising strategy for the prevention and eradication of biofilms, thereby decreasing the incidence of implant-associated infections. The aim of this study was to evaluate the antibacterial properties and *in vivo* efficacy of photoactive 3D-printed poly(lactic acid) (PLA) materials whose surface was modified with saponite, polydiallyldimethylammonium cations, and the photosensitizer Phloxine B.

Three types of samples with different numbers of deposited layers (5,10 and 20) were prepared. The focus of the study was the assessment of biocompatibility and antimicrobial efficacy *in vivo* using the *Galleria mellonella* model. A clinical strain *S. aureus* EDCC 5055 was preincubated with prepared implants (0.8 mm thickness, 6 mm length) to allow bacterial adhesion to the implants. Selected samples were irradiated with a green laser (λ = 532 nm, 100 mW) prior to implantation into *G. mellonella* larvae. In parallel, antibacterial activity was evaluated by determining CFU per implant. Larval survival was monitored for 5 days. All tested materials demonstrated good biocompatibility in the *G. mellonella* model. The implants exhibited strong antibacterial activity *in vitro* against planktonic bacterial cells, with more than 95% growth inhibition observed. Larvae implanted with laser-irradiated samples showed significantly improved survival, exceeding 40 % compared to the unmodified control group. UV-Vis spectroscopy confirmed the release of Phloxine B from the samples during 30 min of pre-incubation with bacterial cells.

The preliminary results highlight the potential of photoactive surface modifications as an effective strategy for the prevention of implant-associated infections.

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RETENTION OF PER- AND POLYFLUOROALKYL SUBSTANCES BY MINERAL AND ORGANIC SURFACES: THE ROLE OF ANIONIC CLAYS

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KEYWORDS: Per- and polyfluoroalkyl substances | Sorbents | Removal | Anionic clays

Per- and polyfluoroalkyl substances (PFAS) are persistent contaminants whose mobility, leaching behavior, and remediation efficiency are controlled by interactions with solid surfaces. Their sorption depends on chain length, functional group chemistry, surface charge, hydrophobicity, and solution chemistry, including competing ions. PFAS retention is strongly structure-dependent, with long-chain compounds generally showing stronger sorption than short-chain analogues, while sorbent properties and solution chemistry can substantially modify these trends [1-3]. Therefore, this study investigated the retention of structurally different PFAS, namely PFOA, PFOS, PFBA, PFBS, PFHxA, and PFHxS, using selected organic- and mineral-based sorbents. In general, organic-based materials showed the highest removal potential, although their efficiency varied with material properties and PFAS structure. Short-chain PFAS retention remained limited, confirming that these compounds are difficult to immobilize by conventional sorbents. Most mineral phases showed limited retention, suggesting that their surfaces did not provide favorable sites for the studied anionic PFAS species. In contrast, LDH materials were the main exception among inorganic sorbents, showing partial retention of selected PFAS. This suggests that anionic clays may provide specific retention sites for some PFAS. Future work should thus focus on optimizing LDH composition, including the development of LDH-organic composites. Nevertheless, testing in real contaminated water and multi-contaminated soil matrices will be necessary to evaluate stability, long-term effectiveness, and practical applicability under environmentally relevant conditions.

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PHOTODYNAMIC INACTIVATION OF SINGLE AND MIXED CANDIDA ALBICANS BIOFILMS USING PHLOXINE B ALONE AND FUNCTIONALIZED IN A NANOCOMPOSITE

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KEYWORDS: Organoclay |*Candida albicans* | *Staphylococcus aureus*| Anti-Biofilm Properties

Candidiasis and infections caused by *Staphylococcus aureus* are often linked to biofilm formation, which increases antimicrobial resistance and complicates treatment. Photodynamic inactivation (PDI) represents a promising alternative antimicrobial strategy.

This study evaluated the effect of phloxine B (PhB) on 24-h biofilms of *Candida albicans* SC 5314 and resistant *Candida albicans* CCY 29 3-164, as well as on 48-h mixed biofilms of *C. albicans* and *Staphylococcus aureus* CCM 3953. Biofilms were treated with PhB (0.5–0.05 mM), incubated for 2 h, and irradiated with a green laser (532 nm, 65 mW/cm², 5 min). PDI with 0.5 mM PhB significantly reduced survival in single-species yeast biofilms to 44.9% (SC 5314) and 26.22% (CCY 29 3-164). In mixed biofilms, survival decreased to 18.87% and 0.64% for *C. albicans* and *S. aureus*, respectively, compared to the controls. Based on these findings, a polyurethane modified with organoclay (ODTMA/Saponite = 0.8 mmol/g) and with functionalised PhB (n_{PhB}/m_{Sap} ratio = 0.21 mmol/g) was developed. UV/Vis spectroscopy confirmed successful PhB incorporation. The nanocomposite effectively reduced growth in 24-h mixed biofilms, corresponding to an inhibition of about 30% and almost 100% for *C. albicans* and *S. aureus,* respectively. Scanning electron microscopy showed disrupted cells and lower biofilm density after irradiation.

Overall, these results highlight the strong potential of light-activated PhB-based nanocomposites as an alternative approach to fight biofilm-associated infections.

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SYNTHESIS OF PHOTOLUMINESCENT MATERIALS BASED ON RARE EARTH ELEMENT MODIFIED SMECTITES

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KEYWORDS: Smectite | Dysprozium | Rare earth elements | Fluorescence spectroscopy

Preparation of modified form of trioctahedral smectite Sumecton-SA by cation exchange reaction using Dy^{3+}cation as rare earth elements probe was investigated with subsequent heat treatment on the structural and photoluminescent properties of the resulting phosphor materials prepared. The samples were processed at different final temperatures (750°C and 1200°C), while two different heating modes were used i) 1-hour lasting conventional sintering (after 10°C/min heating ramp) and ii) 1-minute lasting rapid sintering using fast heating (with ramp reaching 40-100°C/min). After the thermal treatment, the changes in the physicochemical properties of the materials prepared were evaluated using Infrared spectroscopy with Fourier transformation, thermogravimetric analysis, X-ray powder diffraction, fluorescence spectroscopy and fluorescence measurements of lifetimes [1].

The results confirmed that the modification of smectite with Dy^{3+} cations and the subsequent heat treatment led to significant changes in the structure of the material, which are related to the gradual removal of water, dehydroxylation, the disappearance of the original layered arrangement and the formation of new high-temperature phases. These structural changes were also reflected in the photoluminescence properties of the prepared samples. Heat-treated materials showed a characteristic emission of Dy^{3+} ions in the visible region of the spectrum, while the most pronounced emission intensity was observed in samples treated at a higher temperature used. The results of the work confirmed that an appropriately chosen heat treatment can improve the photoluminescence properties of Dy^{3+}-phosphors prepared from synthetic smectites and can significantly shorten their preparation time. In addition, it was found, that for fast sintered sample, the average lifetime of Dy^{3+} excited states was improved by ~4 % in comparison to conventional sintering heating processing used.

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DEVELOPMENT OF A THIN FILM BASED ON QUATERNIZED CHITOSAN, SMECTITE, AND THYMOL

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KEYWORDS: N,N,N-trimethyl Chitosan | Smectite | Layer-by-layer method| Thymol

N,N,N-trimethyl chitosan (TMCH) is an antibacterial, biocompatible, biodegradable, and highly bioadhesive polymer. In a previous study, thin films of TMCH and smectite with different cation exchange capacities were used to prepare hybrid systems via the layer-by-layer (LBL) method. In the mentioned study, Sumecton SA (S; *CEC* = 0.72 mmol/g) and montmorillonite Lutila from a new Slovak deposit (Lu; *CEC* = 1.14 mmol/g) were used, and it was observed that a thicker film with better antibacterial activity was formed with montmorillonite Lu, which has a higher layer charge. For this reason, montmorillonite Lu was chosen for further research on thin films. In general, TMCH is considered hydrophilic, but due to the presence of CH_3 groups, it also forms hydrophobic microdomains that can interact with hydrophobic thymol (Th), which is known for its antiseptic effects. The objective of the study was to improve the antibacterial activity of the film based on TMCH and Lu through Th. The polypropylene slide (PP) used as a substrate for LBL films was activated by DCSBD plasma for 20 s in ambient air, then immersed in TMCH solution. After activation, the PP was immersed in a Lu stock solution, then in TMCH, and finally in Th solution. This constituted the first layer of the LBL film. The film was prepared by alternating layers of negatively charged Lu with cationic TMCH molecules and hydrophobic Th, until a total of 40 LBL layers were achieved. Infrared spectra were measured by the ATR method after the deposition of each five layers. The most significant changes were observed in the 800–1200 cm^{-1} region. These changes were attributed to Si-O stretching vibrations of smectites and C-O stretching vibrations of TMCH. As the number of layers increased, the region's area increased linearly. IR spectroscopy was also used to monitor Th molecules in the system. The new bands, or shoulders, respectively, occurred near 1420, 1160, 945, and 807 cm^{-1} and originated from the phenol ring and CH_3 groups of Th. Compared to the Lu-TMCH sample without Th, a change in TMCH/Lu ratio was also observed. The proportion of the area in the 800–1200 cm^{-1} region relative to the intensity of the OH structural band of montmorillonite at 3625 cm^{-1} increased, indicating an increasing proportion of TMCH relative to Lu. The antibacterial activity of the prepared sample was also tested, and a decrease in biofilm cell growth from 32% for Lu-TMCH to 14.4% for the Lu-TMCH-Th sample was observed.

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NEAR-IR SPECTROSCOPY IN ORGANOCLAYS STUDIES

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KEYWORDS: Smectites | Alkylammonium cations | Polymers | Vibrations

The modification of clay minerals with variuous organic species is an interesting research subject because these materials found application in different areas of industry and environment protection. Most often used modifiers of clay mineral are quaternary alkyl ammonium or phosphonium cations but in recent years water-soluble cationic polymers from the oxazoline group are also extensively studied. This work introduces the major benefits of near-infrared (NIR) spectroscopy in research of organo-montmorillonites (O-Mt). Based on the stretching (ν) and bending (δ) vibrations observed in the Mid-IR region, the first overtone (2νXH) and combination (ν+δ)XH modes of XH groups (X = O, C, N) could be identified.

The basic structural and vibrational characteristics of the samples prepared from two series of structurally analogous alkylammonium- and alkylphosphonium-montmorillonites were evaluated also by NIR spectroscopy. The C-H overtone region revealed the impact of the different central atom (N/P) of the cation head-group on the position of the complex 2νC-H band. As a result of differences in the charge density of the nitrogen and phosphorus cationic centers the positions of the C–H band of phosphonium-Mt was shifted to lower wavenumbers compared to their ammonium counterparts.

The effect of the surfactant size on the extent of Mt dissolution in HCl was confirmed for O-Mt prepared from Na-Mt and tetraalkylammonium salts of different size. A new band near 7315 cm^{-1} due to SiOH overtone revealed creation of reaction product, protonated silica phase. The less stable were O-Mt with shorter alkyl chain, the least structural modification was observed for samples with bulkier alkylammonium cations covering the inner and outer surfaces of montmorillonite preventing the access of protons to the layers protecting thus the mineral from degradation in the acid.

The NIR spectroscopy confirmed the presence of intercalated poly(2-methyl-2-oxazoline) (PMeOx) in Na-Mt. After PMeOx intercalation the intensity of the 2νOH band, present in Na-Mt at 7075 cm^{-1}, was reduced, indicating at least partial substitution of H_2O with PMeOx. The CH first overtone region of the samples showed a shift of the $2\nu_{as}$C-H bands to lower positions with increasing concentration of polymer. At low PMeOx loading, the positions of the 2νCH bands were affected by the interaction of the CH groups with the basal oxygens of the Mt layers. A downward shift the 2νCH bands indicated prevailing interaction among PMeOx chains located either in Mt interlayer or on the outer surfaces. The presented results widen the knowledge on the interactions between organo-species and montmorillonite essential for designing novel applications of composite materials.

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QUANTUM DOT ATTACHMENT TO THE EDGES OF LAYERED SILICATE

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KEYWORDS: Layered silicate | Quantum dots | Cadmium

Modifying silicate-type materials with silane compounds containing thiol groups significantly enhances their binding affinity for heavy metal ions [1], which is essential for targeted environmental remediation of pollutants. The thiol functional group is well-known for its strong chelating ability with metal ions such as cadmium, owing to the high nucleophilicity of the sulfur atom, which enables the formation of stable covalent and coordinate bonds [2]. By introducing thiol-functionalized silane molecules onto the edges of layered silicates, the edge chemistry of the layered silicates can be tailored to promote selective and enhanced cadmium adsorption.

Furthermore, this modification not only enhances the interfacial interaction between the layered silicate and cadmium ions but also creates well-defined, spatially controlled nucleation centers. These nucleation sites are critical for the subsequent controlled growth of CdTe and CdTe quantum dots, as they dictate the size distribution, uniformity, and crystallinity of the resulting nanostructures. Consequently, the thiol-functionalized silicate edges serve as an efficient and versatile platform that supports the synthesis of quantum dots with optimized optical and electronic properties, which are highly desirable for applications in optoelectronics and artificial photosynthesis.

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THERMAL STABILITY OF SILANE-MODIFIED SMECTITES VIA SIMULTANEOUS THERMO-IR SPECTROSCOPY AND THERMAL ANALYSIS

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KEYWORDS: Smectite | Thermal analysis | Infrared spectroscopy | Silane

Smectite functionalization with organosilanes is an effective strategy for tailoring the surface properties of clay minerals for advanced composite applications. Understanding the thermal stability of silane-modified smectites is an effective method for evaluating their performance under elevated-temperature conditions and for optimizing modification procedures.

The thermal stability of natural and synthetic smectites functionalised with silane was investigated by thermogravimetric analysis (TGA) coupled with an infrared spectrometer and mass spectrometer for analysis of evolved gases. Montmorillonite from Kopernica (Kop) deposit (Slovakia) and synthetic hectorite Sumecton SWN (Japan) were reacted with aminopropyltrietoxysilane (APTES) in the molar amount equal to *CEC*.

The presence of APTES in powder samples was confirmed in their infrared spectra via the appearance of new absorption bands at 1417 cm^{-1} and 1060–1006 cm^{-1} compared with the spectra of pristine smectites. Hydrolysis and condensation reactions that occurred upon silane grafting to smectites change the spectral profile of the bands relative to APTES used for the reaction. Thermal analysis showed mass loss associated with silane decomposition in the temperature range 200-550°C that corresponded to cca 4% for both smectites. The interesting feature observed in DTG profiles was the shift of the layer dehydroxylation process to higher temperatures for samples with APTES present compared to pristine samples. For APTES-Kop, the dehydroxylation peak minima occurred at 745 °C, while for Kop at 667 °C. For SWN dehydroxylation, minima shifted from 690 to 760 °C in the profile of APTES-SWN.

Infrared spectra of vapour phase released from the samples showed the presence of the absorption bands assigned to stretching and bending vibrations of water molecules released during the dehydration process at lower temperatures, and CO_2 in a temperature range associated with silane-based phase decomposition. For APTES-Kop, the release of the organic phase was also detected from the presence of the bands around 3000 cm^{-1}. The temperature of maximum intensity of the bands attributed to silane-derived phase evolution was consistent with the temperature of maximal mass loss rate detected from DTG profiles. These maxima were recorded at 364 °C for APTES-Kop, while APTES-SWN exhibited two maxima at 232 and 450 °C.

The results demonstrated successful APTES functionalization of both smectites and revealed significant changes in their thermal behaviour upon silane grafting. The combined TG-FTIR analysis provided useful information on the decomposition pathway of silane-modified smectites and the nature of evolved gaseous products.

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UNRAVELLING CHARGE INTERACTIONS IN SMECTITE-LUMINOPHORE HYBRIDS: ADVANCING PHOTOACTIVE MATERIALS

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KEYWORDS: Benzothiazole derivates | Layered Silicates | Photophysical Properties | Charge interactions

Electrostatic interactions between cationic organic dyes and the negatively charged surfaces of smectites represent the dominant mechanism governing the formation of photoactive hybrid systems [1]. Previous studies have demonstrated that varying the layer charge density of smectites enables control over intermolecular dye spacing on the subnanometer to nanometer scale, thereby significantly affecting dye aggregation behaviour [2]. Although surface charge density is known to influence the arrangement and optical properties of luminophores, systematic investigations into the interplay between the charge distribution of dye molecules and the surface charge distribution of smectites remain limited.

In this study, we investigated mono- and polyvalent cationic dyes ([D-TPA-Btz-Me]$^{+}$, [Q-TPA-Btz-Me]$^{2+}$, and [O-TPA-Btz-Me]$^{3+}$) in combination with smectites exhibiting different surface charge densities. The selected dyes were specifically designed to minimise aggregation effects, with particular emphasis on surface-fixation-induced emission (S-FIE). Hybrid materials were prepared as thin films and dispersions, and their photophysical properties were monitored over an extended period of up to 21 days.

Results revealed a pronounced effect of dye charge on molecular migration processes at the smectite surface. In systems containing monovalent cations, these processes were reflected in shifts of the absorption maxima, whereas systems incorporating polyvalent cations exhibited enhanced long-term stability. Furthermore, all systems containing synthetic smectites showed a gradual increase in photoluminescence intensity over time, which may be attributed to smectite particle agglomeration and the intercalation of dye molecules into the interlayer space. Hybrid systems containing natural smectites exhibited scattering in the absorption spectra and emission quenching; therefore, they are not suitable for the preparation of photoluminescent materials.

Overall, the findings provide general design principles for the development of photoactive hybrid materials with tunable and predictable properties.

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PREPARATION AND CHARACTERISATION OF MNT/PQ-2 NANOCOMPOSITES

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KEYWORDS: Montmorillonite | Polyquaternium-2 | X-ray diffraction | Infrared spectroscopy

Clay minerals are natural nanomaterials often used to preparation of nanocomposites. Nanocomposites have extraordinary physical and chemical properties, which are derived from their size in the nanoscale. They are defined as unique chemical conjugates of organic and/or inorganic materials [1]. Frequently and systematically studied systems are nanocomposites of clay minerals with cationic polymers, such as chitosan, polyethyleneimine or poly(4-vinylpyridinium) salts. Nanocomposites composed of clay mineral and cationic polyelectrolyte have wide applications in various fields. They can be used as adsorbent of organic pollutants in agriculture, water treatment, for biomedical applications as drugs carrier, for instance [2].

In this work we present for the first time the findings of the study of nanocomposites consisted of layered silicate – montmorillonite (Mnt) and polyelectrolyte – polyquaternium-2 (PQ-2). Solid samples in the form of powders were used for infrared spectroscopy (IR), samples in the form of thin films were used for X-ray diffraction (XRD) measurements.

Based on the size of the interlayer space (14 – 15 Å), we assume that the monolayer arrangement of the polymer chain is present in all prepared samples. No further changes in XRD patterns of Mnt modified with PQ-2 loadings above 2.5 mmol·g^{-1} indicated that polymer could be adsorbed on the outer surface of Mnt. XRD analysis combined with MIR and NIR spectroscopy provided fundamental information on the changes of the polymer chain conformation. The vibration bands of CH_2 groups were shifted from higher to lower wavenumbers with increasing loading of PQ-2, reflecting the increase in the amount of ordered *trans* conformers on the expense of disordered *gauche* conformers. When the loading of PQ-2 was higher than 4.5 mmol·g^{-1} no further shift of the absorption band in IR spectra was observed, so it can be assumed that the polymer conformation was unchanged over this loading.

PQ-2 polymer exhibits significant antimicrobial activity against both Gram-positive and Gram-negative bacteria as well as methicillin-resistant *Staphylococcus aureus*. Polyelectrolyte immobilized on the surface of montmorillonite could exhibit strong bactericidal activity the prepared composite nanomaterial would be suitable for the preparation of functional surface with antimicrobial properties.

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STRUCTURE'S REFINEMENT OF INTERCALATED CLAY MINERALS BY THE DFT METHOD

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KEYWORDS: Clay minerals | Hectorite | Vermiculite | DFT

In spite of the wide use of clay minerals in the industry and also in remediation processes, their structural characterization is very difficult because of the poor crystallinity of these materials. The information obtained from powder X-ray measurements is often insufficient. Because the positions of hydrogen atoms cannot be determined, for example, and details about the hydrogen bonding of the intercalated molecules are missing. Only the still relatively rare neutron powder diffraction experiments provide such data. Using computational methods enables researchers to investigate how organic cations behave within the clay mineral structure. Gaining insight into the behavior of species confined in the interlayer space makes it possible to optimize intercalation conditions and tailor the resulting materials to achieve the desired performance. The computational method based on Density Functional Theory (DFT) for solid state implemented in the VASP program package [1] can refine the structures of clay minerals and their organoclays.

For example, the final structural refinement of hectorite (H) intercalated by tetramethylammonium (TMA) cations could not be achieved experimentally. The DFT calculations of all possible H-TMA structures, according to the symmetry rules, revealed the most stable positions of TMA cations and hydrogen atoms in the hectorite interlayer space [2].

Another case study was the elucidation of the amount of the TMA cations in the vermiculite (V) structure. The experimental structure showed four possible TMA cations in the interlayer space, but calculations revealed the stable hybrid V-TMA structure with only two TMA cations. Further, the amount of water in the interlayer space of V-TMA influences the stability of this hybrid structure. The higher the amount of water, the lower the stability of the V-TMA hybrid system [3].

The DFT method for solid state provides valuable results and is a useful tool for obtaining additional information on clay mineral structures.

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ENHANCEMENT OF LUMINESCENCE EFFICIENCY OF AN IRIDIUM(III) COMPLEX VIA ADSORPTION ON LAYERED SILICATE PARTICLES

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KEYWORDS: Phosphorescence | Ionic transition metal complexes | Light-up effect | Smectites

Cyclometalated iridium complex molecules, due to their interesting photophysical and electrochemical properties, represent a promising group of photosensitising compounds and have great potential for use as phosphorescent emitters in light-emitting electrochemical cells.

The subject of our research was the red-emitting complex cation $[Ir(ppy)_2(dbzt)]^+$ (IrC, where ppy = 2-phenylpyridine and dbzt = 2,2′-dibenzothiazole) and its *tert*-Butyl (*t*Bu) analogues, which, together with synthetic saponite (Sap), were used to prepare organometallic-layered silicate hybrid systems. The aim was to describe the influence of the surface concentration of adsorbed complex cations (a_{IrC}) and the presence of sterically demanding electron-donating groups within the complex structures on the photophysical properties of the studied dispersions using UV-Vis absorption spectroscopy, steady-state fluorescence spectroscopy, and time-resolved luminescence measurements. The concentration of the Ir(III) complex was identical in each dispersion (2.5 μM), while different values of a_{IrC} (ranging from 0.003 mmol g^{-1} to 0.57 mmol g^{-1}) were achieved by varying the Sap concentration in the systems.

For solutions of Ir(III) complexes in a mixture of H_2O – DMSO (9:1, *v*/*v*), a large Stokes shift and light emission in the red to near-infrared region of the spectrum were observed. With an increasing number of *t*Bu substituents on the dbzt ligand, a hypsochromic shift of the emission band and an increase in the emission intensity of the complex were observed. The interaction of Ir(III) cations with Sap nanoparticles in the case of each complex led to adsorption-induced emission enhancement (AdIEE), while the photoluminescence quantum yield (PLQY) and the excited-state lifetime of the complexes slightly decreased with increasing a_{IrC} in the hybrid dispersions. The AdIEE phenomenon was most pronounced in the dispersion of the unsubstituted $[Ir(ppy)_2(dbzt)]^+$ complex with Sap at the lowest a_{IrC} (PLQY = 3.6%), where adsorption led to a 20-fold increase in PLQY compared to its solution (PLQY < 1%). The extent of luminescence enhancement of individual *t*Bu analogues of the IrC complex decreased with an increasing number of substituent groups attached to the dbzt ligand, indicating that the presence of sterically demanding groups in the structure of the complex cation leads to the suppression of the AdIEE phenomenon.

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PRESENT POTENTIAL OF CLAY RAW MATERIALS IN THE FIELD OF BUILDING MATERIALS

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KEYWORDS: Building materials | Clay raw materials | LWA | SCM

Clay has been utilized as a construction material for more than 9,000 years and historically represented the principal building material in dry tropical and temperate climatic regions [1]. In Central Europe, however, the traditional use of clay in vernacular architecture gradually declined during the 19th century, primarily due to the development of industrial manufacturing processes for construction materials, including fired bricks and, subsequently, concrete.

In recent decades, increasing environmental concerns and the growing emphasis on sustainability in the construction industry have renewed interest in clay-based building materials because of their favorable environmental and technical properties. Nevertheless, earth-based materials are currently unable to replace cement-based products, which continue to dominate the construction sector due to their superior mechanical performance and durability. A major disadvantage of cement-based materials is their significant environmental impact associated with high CO_2 emissions during production. One of the most effective and economically feasible approaches to decarbonization in the cement industry is the partial replacement of clinker or cement with supplementary cementitious materials (SCMs). Among the various SCMs, calcined clays are presently considered to possess substantial potential owing to their widespread availability and relatively low cost [e.g. 2].

Another strategy for reducing CO_2 emissions involves the development of more energy-efficient construction materials with enhanced thermal insulation properties. Lightweight aggregate concrete, containing lightweight aggregates (LWA), represents a suitable material for thermally insulating structural components due to its increased porosity and reduced density. Clays constitute the most commonly used natural raw materials for the production of lightweight aggregates [e.g. 3].

The primary objective of the present project is to evaluate the potential utilization of selected Slovak clay raw materials in construction applications, particularly as SCMs and LWA. Emphasis is placed on raw materials originating from deposits with sufficient reserves, while also considering lower-quality materials that currently lack industrial utilization. To date, a total of 21 deposits have been selected for investigation, including three bentonite deposits, four ceramic and refractory clay deposits, two kaolin deposits, nine brick clay deposits, and three marl deposits.

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APPLICATION OF HYDROTALCITE-LIKE COATING AS A PROTECTIVE BARRIER AGAINST CORROSION OF ZINC SUBSTRATE – ADHESION AND DURABILITY STUDY

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KEYWORDS: Hydrotalcite-like coating | Zinc | Adhesion| Scratch resistance| Corrosion resistance

The growing demand for effective and environmentally friendly corrosion protection methods has intensified research on Layered Double Hydroxide (LDH) coatings used on metallic materials [1,2]. In this study, hydrotalcite-like coatings were formed on zinc substrates to evaluate their potential as anti-corrosion barriers. Particular attention was paid to the adhesive and nanomechanical properties of the coatings, which determine their durability and quality.

The coatings were synthesized via a hydrothermal method, resulting in a compact, uniform LDH structure on the zinc surface. Subsequently, vanadate ions were then introduced as corrosion inhibitors via an ion-exchange process. Morphological and structural characterizations were carried out using scanning electron microscopy (SEM-EDS), X-ray diffraction (XRD), and infrared spectroscopy (FTIR). The investigations confirmed the successful formation of a coating with a layered LDH structure, which was retained even after the introduction of the inhibitor. The hardness and elastic modulus of the coatings were determined by nanoindentation using a Berkovich indenter. Adhesive properties were evaluated by scratch tests using a Rockwell indenter, and demonstrated good coating adhesion to the substrate. Corrosion resistance tests revealed that the LDH coating limits corrosive activity by hindering the penetration of aggressive ions and improving the barrier properties of the zinc substrate. The coatings were relatively stiff, and their plate-like morphology contributes to cracking of the top surface layers during indentation. Despite their brittleness, the coatings exhibited good adhesion to the zinc substrate, confirming the effectiveness of the applied synthesis method. The wear of the coatings in frictional contact with the spherical indenter was mainly abrasive in nature; however, it was initiated by coating cracks and local micro-chipping.

The conducted investigations confirmed that the produced coatings retained satisfactory mechanical properties and adhesion to the substrate. Hydrotalcite-like coatings represent a promising solution for enhancing the corrosion resistance of zinc-based materials, and may find applications in surface protection engineering.

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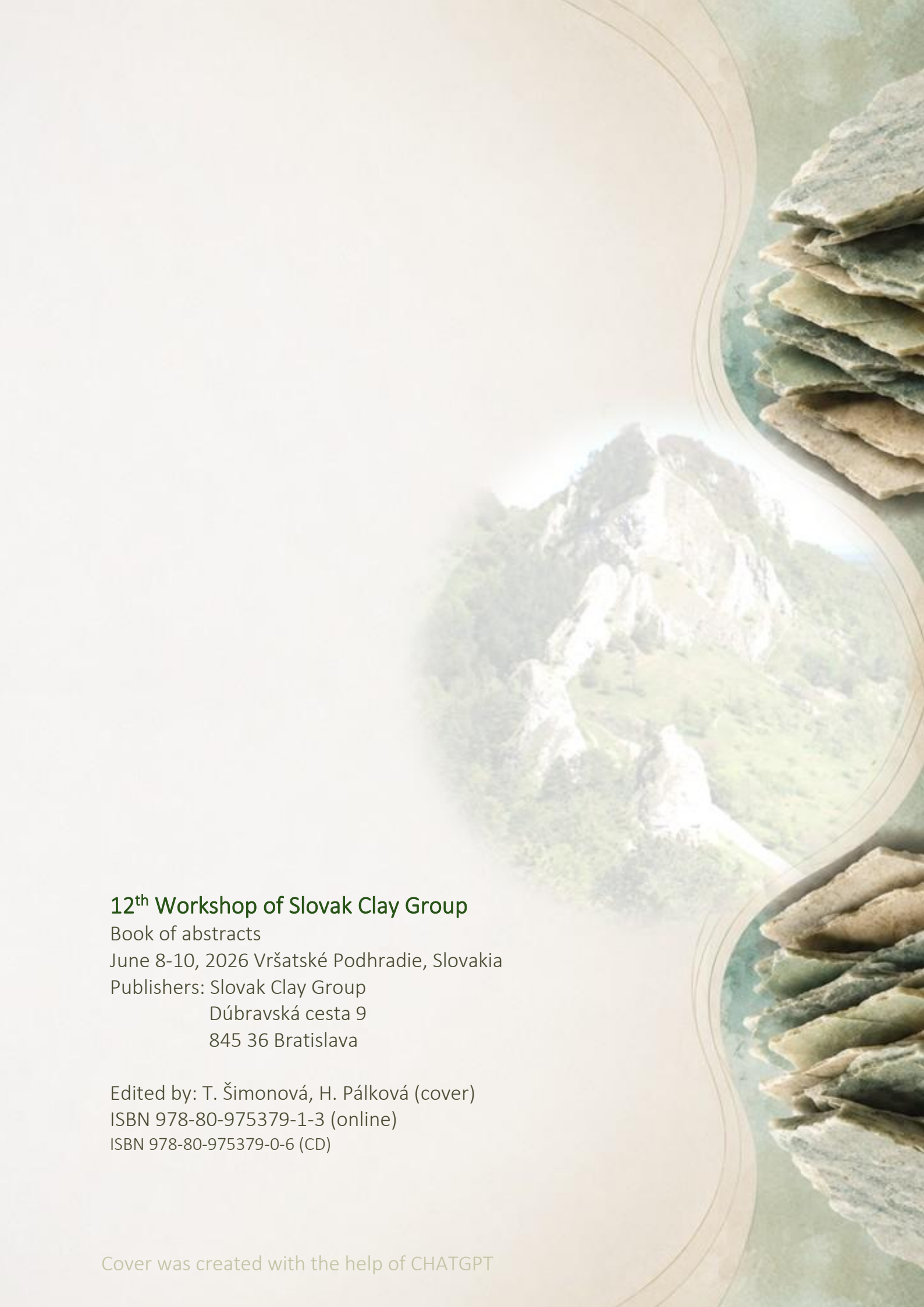

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