Project No. 02504

Report form of Joint Research Project at ZAIKEN (FY2025)

Title of Project	**Use of organo-nanosheets in water remediation**		
Priority Area	**II-A(Prolongation of service life & Structures), II-A(4R & Processes), II-B(4R & Structures)**		
New proposal			
Name of Main Applicant	**GUEGAN Régis**		
Institution	**University of Orléans (France)**	**title**	**Dr. (Ass. Prof.)**
Name of the host faculty at Waseda	**Prof. SUGAHARA Yoshiyuki**		

Aim of the research project

The widespread contamination of aquatic environments and drinking water by persistent pollutants, including nanoplastics, pharmaceuticals, and per- and polyfluoroalkyl substances (PFAS), represents a major environmental and public health challenge. Among these contaminants, nanoplastics are of particular concern because of their extremely small size, persistence, and ability to adsorb and transport toxic organic pollutants as well as pathogenic microorganisms throughout aquatic ecosystems and food chains. Their detection and removal remain highly challenging using conventional water treatment technologies.

In response to these critical issues, this project aims at developing innovative hybrid nanocomposite materials based on inorganic nanosheets, including graphene oxide and layered phyllosilicates, combined with tailored organic surfactants for the efficient adsorption and removal of nanoplastics of different sizes and chemical compositions from water. By combining a large specific surface area, diverse adsorption sites, ion-exchange properties, and tunable hydrophobic interactions of the different building blocks, these multicomponent materials are expected to exhibit enhanced adsorption performances toward persistent plastic nanoparticles.

The project will also provide a comprehensive physicochemical characterization of the synthesized nanocomposites before and after nanoplastic adsorption using advanced analytical techniques, including electron microscopies, X-ray diffraction, , small-angle X-ray scattering, and vibrational (FTIR) and UV spectroscopies. Ultimately, this research aims to develop sustainable (4R) adsorption technologies for nanoplastic remediation, contributing to improved water purification processes, the protection of aquatic ecosystems, and the preservation of drinking water resources.

Contents and results of the research

1. Different organoclays were prepared by using different cationic and nonionic surfactants (different nature and hydrophilic lipophilic balance) (probably further surfactants will be investigated)
2. The structural organization of the organoclays was investigated by complementary techniques: XRD, FTIR confirming the proper intercalation of the surfactants within the interlayer space of the layered materials (almost achieved)
3. The resulting hybrid materials were then dispersed in aqueous media, and their zeta potentials were then characterized (almost completed)
4. The hydraulic conductivity of the different collected hybrid materials were also characterized and compared to the pristine layered materials (need further experiments)
5. The SEM and TEM observations of the polystyrene (PS) beads of different sizes (20, 50, 80, 200 nm) which were corroborated to that determined by DLS (need further experiments)
6. The Zeta potential of the PS beads were also determined and UV characterization of the dispersions of the nanoplastics was also achieved (almost completed)
7. Batch experiments of the adsorption PS nanobeads (20, 50 nm) at different concentrations onto pristine clay minerals and their organo-layered analogous were studied (need further experiments)
8. Expected adsorption isotherms will be determined to precisely quantify the of PS beads to the layered materials (not completely achieved)
9. The different hybrid materials (pristine clay minerals and organoclays) after being in contact with the PS beads were characterized by a set of complementary techniques for a complete understanding of the affinity of the nanoplastics (need further investigations)
10. Dynamic adsorption experiments of PS beads on the layered materials

In addition to the proposal, my stay at Zaiken allows me to discuss with the research group of Prof. Sugahara about different projects related to the Janus nanosheets and titania nanosheets.

Outputs of the project (publications, presentations, patents)

It is still too premature to expect any potential outputs of the project but we are working on it