ADSORPTION OF POLYETHYLENE TEREPHTHALATE, POLYSTYRENE, AND POLYETHYLENE NANOPLASTICS FROM FRESHWATER SYSTEMS

Mahrosh Javed[1], Galina Lujanienė[1], Sergej Šemčuk[1], Vidas Pakštas[2], Martynas Talaikis[3], Aušra Selskienė[2]

[1]Center for Physical Sciences and Technology, Department of Environmental Research, Vilnius, Lithuania
[2]Center for Physical Sciences and Technology, Department of Characterization of Materials Structure, Vilnius, Lithuania
[3]Center for Physical Sciences and Technology, Department of Organic Chemistry, Vilnius, Lithuania
mahrosh.javed@ftmc.lt

Over 335 million tonnes of plastic have been produced worldwide. Plastic waste has been recognized as a global environmental problem, and improper handling of this waste has led to increasing amounts of plastic debris. Upon entering the aquatic environment, this debris undergoes chemical and physical processes caused due to aging by UV light and abrasion by waves, forming microplastics (>5 µm) and nanoplastics (>1 µm). Excessive release of these particles has polluted water systems. Ingestion of these plastic particles is reported to cause health risks to living cells. Therefore, removing nanoplastics from water systems is essential to ensure the safety of human health and aquatic [1]. Recent studies have employed various water treatment techniques to extract nanoplastics from water. Among these, adsorption offers several advantages, including the use of environmentally friendly materials, high efficiency, and simple operation. Various adsorbents, such as biochar, clay, silica, polysaccharides, zeolites, and graphene-based materials, have been used to remove nanoplastics. Graphene has also been reported to be a good adsorbent in the removal of pollutants with functional groups like carbonyl, hydroxyl, epoxy, and carboxyl. Nevertheless, graphene oxide (GO) has several layers, resulting in aggregation, thus complicating adsorption. In this regard, natural polymers like cellulose and chitosan (CS) can be functionalized to develop a composite with various functional groups and increased capacity of adsorption. Cellulose is an inexpensive and biodegradable substance that does not produce toxins, has a large adsorption capacity because of the presence of hydroxyl groups (-OH) in it, creating adsorption sites on its surface[1]. Because of a similar polysaccharide nature, chitosan also has these advantages and additional amino (-NH 2) groups obtained as a result of the chitin deacetylation process, and this further enhances its adsorption properties [2]. Microcrystalline cellulose (MCC) and chitosan (GO) composites were developed in this work to eliminate the nanoplastics, such as polyethylene terephthalate (PET), polystyrene (PS), and polyethylene (PE). GO was produced through a modified Hummer's method. MCC was first mercerised and then crosslinked with GO to create MCC-GO composites [3]. In the case of GO-CS, chitosan was dissolved in acetic acid and then crosslinked through glutaraldehyde [2]. SEM, XRD, and FT-IR were used to characterise the prepared composites. The nanoprecipitation method was used to produce nanoplastics, which were characterised by TEM and FT-IR. The surface charge of all the adsorbents prepared, as well as the nanoplastic,s was determined by calculating the point of zero charge (pHPZC). The synthesis of nanoplastics was confirmed by characterisation. The synthesised composites were used for nanoplasticadsorption. UV-VIS spectroscopy was used to monitor all the changes during the adsorption process.

Keywords: Nanoplastics, Adsorption, Water, Chitosan, Cellulose

[1] M. Javed and G. Lujanienė, "Nanoplastics in aquatic systems: challenges and advances in adsorptive removal technologies," Frontiers in Water, vol. 7, Jun. 2025, doi: 10.3389/frwa.2025.1611558.
[2] M. Sabzevari, D. E. Cree, and L. D. Wilson, "Graphene Oxide–Chitosan composite material for treatment of a model dye effluent," ACS Omega, vol. 3, no. 10, pp. 13045–13054, Oct. 2018, doi: 10.1021/acsomega.8b01871.
[3] A. Boudjellal, D. Trache, K. Khimeche, S. L. Hafsaoui, and M. S. Razali, "Preparation and characterization of graphene oxide-based natural hybrids containing alfa fibers or microcrystalline cellulose," Journal of Natural Fibers, vol. 19, no. 13, pp. 5321–5332, Feb. 2021, doi: 10.1080/15440478.2021.1875373.