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Acute Toxicity of Nano-Polystyrene in the Presence of Environmental Polysaccharides: Investigating Cellular Interactions and Membrane Disruption

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ABSTRACT

The global crisis of plastic pollution is intensifying, with microplastics and nanoplastics emerging as significant environmental and health concerns[1]. Recent research indicates that humans may consume approximately 5 grammes of plastic every week[2], which is equivalent to the weight of a credit card. Additionally, researchers have identified nanoplastics in every human brain and testicular sample they have examined, raising concerns regarding their potential biological effects[3, 4]. Additionally, inflammatory bowel disease (IBD) has been associated with microplastics[5]. Nevertheless, the acute toxicity mechanisms of nanoplastics, particularly in the presence of naturally occurring environmental compounds like polysaccharides, are still inadequately understood[6].

This study examined the acute toxicity of fluorescence yellow-green labelled nano-polystyrene (nPS) in the presence of three environmental polysaccharides: agarose, carrageenan, and sodium alginate. Our primary goal was to ascertain whether these polysaccharides have an impact on the toxicity of nPS, potentially exacerbating its detrimental effects. To evaluate the stability and aggregation behaviour of nPS in artificial seawater described in the ISO 21115:2019 protocol[7] under varying conditions, the research entailed dynamic light scattering (DLS) measurements, both individually and in conjunction with the selected polysaccharides.

To assess the toxicological impact, this study adapted the ISO 21115:2019 protocol[7], which evaluates the acute toxicity of waterborne compounds using the RTgill-W1 fish gill cell line. This research explored cellular responses at multiple time points, thereby providing a more comprehensive toxicity profile, in contrast to the standard protocol, which assesses toxicity exclusively at 24 hours. Alamar Blue was utilised to evaluate metabolic activity, 5-CFDA-AM to assess membrane integrity, and Neutral Red to examine lysosomal stability. Three fluorescent indicators were employed to evaluate various aspects of cell health. The fluorescence labelling of the nanoparticles is used to analyse cellular irregularities and interactions between nPS and RTgill-W1 cells using flow cytometry.

The behaviour and toxicity of nPS may have been altered by the presence of specific polysaccharides, either by modifying its cellular absorption or by influencing its aggregation state. Additionally, researchers are currently investigating the potential of polysaccharides as environmentally benign bio-adsorbents for wastewater remediation. This method could unintentionally exacerbate environmental impacts, making the situation more challenging to control, if the interactions between nanoplastics and polysaccharides remain inadequately understood. Furthermore, the results of the flow cytometry closely correspond with the findings of the membrane integrity assay, indicating that the primary mode of toxicity for nPS exposure is the disruption of cellular membranes rather than the impact on metabolic activity or lysosomal stability. This suggests that the toxic effects observed may be significantly influenced by the interaction between nPS and the cell membrane, which may be the result of the direct association of nanoparticles with the cell surface or changes in membrane permeability.

KEY WORDS

Nanoplastics, polysaccharides, toxicity.

BIOGRAPHY

Quang Minh Luu is a PhD candidate in Environmental Science who specialises in the environmental effects of nanoplastics. His research is dedicated to the examination of the ecological and health consequences of the global plastic waste pollution, as well as the exploration of potential strategies to address these issues. Quang's objective is to develop more sustainable solutions for plastic waste management and the reduction of microplastics in the environment.

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1. Galloway, T. S., Micro- and Nano-plastics and Human Health. In Marine Anthropogenic Litter, Bergmann, M.; Gutow, L.; Klages, M., Eds. Springer International Publishing: Cham, 2015; pp 343-366.

2. Senathirajah, K.; Attwood, S.; Bhagwat, G.; Carbery, M.; Wilson, S.; Palanisami, T., Estimation of the mass of microplastics ingested - A pivotal first step towards human health risk assessment. J Hazard Mater **2021,** 404, (Pt B), 124004.

3. Nanoplastics in the human brain and their change in abundance over time. Nature Medicine **2025**.

4. Hu, C. J.; Garcia, M. A.; Nihart, A.; Liu, R.; Yin, L.; Adolphi, N.; Gallego, D. F.; Kang, H.; Campen, M. J.; Yu, X., Microplastic presence in dog and human testis and its potential association with sperm count and weights of testis and epididymis. Toxicological Sciences **2024,** 200, (2), 235-240.

5. Bruno, A.; Dovizio, M.; Milillo, C.; Aruffo, E.; Pesce, M.; Gatta, M.; Chiacchiaretta, P.; Di Carlo, P.; Ballerini, P., Orally Ingested Micro- and Nano-Plastics: A Hidden Driver of Inflammatory Bowel Disease and Colorectal Cancer. Cancers **2024,** 16, (17), 3079.

6. Kelpsiene, E.; Torstensson, O.; Ekvall, M. T.; Hansson, L.-A.; Cedervall, T., Long-term exposure to nanoplastics reduces life-time in Daphnia magna. Scientific Reports **2020,** 10, (1), 5979.

7. ISO_21115:2019, Water quality – determination of acute toxicity of water samples and chemicals to a fish gill cell line (RTgill-W1). In International Organization for Standardisation: Geneva.