Assessing the Influence of Microplastics on the Immune System with Bio-MEMS Technologies

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[Abstract]

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Plastic wastes can be fragmented into small debris. The ubiquitous presence of microplastics (MPs) in the environment is a cause for great concern. This study aimed to develop a method for producing MPs in the micrometer range for various biological tests, where the morphology and constituents of the MPs were guaranteed. The proposed production system was a pin-on-disc machine with multi-directional sliding motions. Pins made of polyethylene, polypropylene, polyvinyl chloride, or polyethylene terephthalate were pressed onto a quartz glass disc under the lubrication of artificial sea water. Micro-textured glass surfaces were prepared by the combined application of a masking process and a micro-slurry jet process for generating particles with various morphologies. Ultraviolet irradiation (UV: 280–315 nm) was performed through the glass disc to the sliding surfaces during fragmentations of the polymer plastics. The UV promoted the fragmentation of polymer plastics. The UV was believed to influence the equivalent circle diameters of MPs but did not affect the aspect ratios and complexity. Differences in the crystalline or amorphous plastic and the copolymer or condensation polymer might affect fragmentation speeds. The morphological aspects of the generated MPs are confirmed to be similar to those of the MPs collected and analyzed in our environments. The transfer and accumulation of MPs in the micrometer range to Caridina multidentate (Arthropod), Eunicidae (Arthropod), Oryzias latipes (Fish), and C57BL6 mice (Normal/Colitis model) were experimentally verified. The MPs were transferred to, and accumulated in, various living organisms. Transferring and microparticle accumulation were observed in not only the digestive system but also the other organs through the vascular system. Human monocyte-derived macrophages (HMDMs) phagocytize various MPs and secrete a number of proinflammatory cytokines. In in vitro experiments, the HMDMs are cultured in a medium with the MPs. However, the MPs suspend or hydrate in the medium or settle out in the medium. These microparticle phenomena show difficulty of elucidating the relationship between the microparticles administrated in a medium and the microparticles phagocytized by HMDMs. A micro-chamber with a height greater than 20 micrometers was fabricated, and the configuration enabled the MPs to pass nearby the HMDMs, which is important in the phagocytosis of MPs. By adopting the culture system, the observation of the phagocytic processing by HMDMs and the evaluation of the time-dependent change of secretion of cytokines were realized.

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