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Cr(III) - Cr(VI): variability of the speciation of chromium released into the environment by microplastic weathering

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The pollution of the environment by an increasing amount of plastic waste is now well established. All environments, water, soil, atmosphere, are contaminated. Biodiversity is therefore potentially at risk, and it is now recognized that the environmental risk is not only due to the presence of plastics but also to their ability to transport and release contaminants, such as metals (1). Metals, both inorganic and organic, are widely used in the formulation of plastic as colorants, anti-oxidants, etc (2). Once released into the environment, plastics are degraded under natural conditions, resulting in the concomitant production of oxidized plastics particles (micro to nano-size) and the release of metallic additives (3). The speciation of metals and how they are trapped in the plastic matrix determine the species and amounts released into the environment.

In a µXRF and µXAS study of long-term photo-oxidation altered polyethylene microplastics collected from the North Pacific gyre, we demonstrated that chromium (Cr) occurs as nanoparticles indifferently distributed or concentrated in pockets inside the polymer matrix. It can be associated with other metals such as titanium, cobalt and lead. Furthermore, different Cr(III) and Cr(VI) species were observed, resulting from the plastic formulation. Chromium nanoparticles are present in the core of plastics as well as in and on the surface of altered surface layers but its speciation is not modified in the altered areas.

Therefore, under oceanic photo-oxidation, chromium can be released as toxic species, relative to its pristine speciation, with the fragmentation of weathered plastic debris.

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