Intentionally added plastics in personal care products – a key source of microplastics to the environment: *An introduction to the effects and mitigation*

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Introduction

It is estimated 12.7 million metric tons (MT) of plastics enter the environment as microplastics every year, the main sources being paint, tyres, pellets, textiles and personal care products [1]. There are substantial additional quantities from the fragmentation of larger items of plastic that have already entered the environment as debris. This document focuses on personal care products, which are estimated to account for an annual release of 0.055 MT [1] of microplastics to the environment. Microplastics are persistent and once in the environment it is not practical to remove them. Hence, interventions to minimise emissions and releases are key. Business-as-usual scenarios suggest the environmental accumulation of microplastics could cause wide scale ecological harm within the next 100 years [2].

Personal care products as a source

A key source is microplastics that are intentionally added to personal care products (PCPs), including "rinse off" products such as cosmetics, sunscreens, antiperspirants, facial scrubs, and soaps, as well as in toothpaste and a range of household and industrial cleaning products. The plastic particles used in these products are typically 1 - 1000 µm in size, and some products can contain millions of plastic particles that are subsequently released to wastewater [3]. Because these particles for these applications are manufactured to be ≤5mm, they are described as primary microplastics.

Microplastics intentionally added in the manufacture of PCPs are typically called "microbeads" and exist in various shapes including ellipses, irregular fragments and spheres [3,4]. In locations that benefit from advanced wastewater treatment, a substantial proportion of larger microplastics (~300µm) may be captured, but uncaptured plastics including smaller pieces pass directly to the environment with 'treated' water [5]. In addition, it is common practice to apply biosolids from wastewater, which include captured plastic particles, to land as fertiliser[6], or to incinerate them, resulting in emissions of carbon dioxide and potentially harmful substances including additional microplastics emissions [7,8,].

Intentionally designed and manufactured microplastics used in PCPs are typically made from polyethylene (PE) (including glitter commonly used in cosmetics), but also include poly (ethylene terephthalate) (PET), nylon, polypropylene (PP) and poly (methyl methacrylate) (PMMA) [3,4]. Like all plastics, once in the environment, microplastics will weather and fragment into smaller particles [9]. They can be redistributed by air, water and organisms, however their heterogeneity results in differing transport potential to that of natural particles [10]. While natural particles are a normal component of ecosystem dynamics and cause minimal harm, there is substantial evidence of toxicity resulting from exposure to microplastics in general [11,12] and to microplastics from PCPs [13]. While there is limited information on the chemical composition of microplastics used in PCPs, plastics more generally can contain mixtures of polymers, unreacted monomers, oligomers, additives, and non-intentionally added substances (NIAS) [14]. Microplastics including those used in PCPs can also accumulate harmful chemicals [3], such as heavy metals and organic pollutants from the environment and may facilitate the uptake of chemicals by organisms [9]. In addition, microbial surface colonisation can result in transport of pathogens including *Vibrio spp*. and *E. coli*, and antibiotic resistance genes [15,16]. A survey in the UK indicated consumers were alarmed about the presence of plastic microbeads in their cosmetics, and the societal benefit of this intentional addition of microplastics was unclear [17].

For plastic particles in PCPs that are applied to the skin, a key pathway into the human body could be via dermal absorption, with concerns being raised in relation to a range of particle sizes such as microplastics in sunscreens[18] and nanoplastics in face-scrubs [19]. However, the importance of this route is yet to be confirmed.

Interventions to eliminate the release of intentionally added microplastics

Regulating and monitoring primary microplastics that are manufactured (≤5mm) and intentionally added to PCPs (Fig. 1) can be relatively straightforward. For example, microbeads added to PCPs have now been banned in at least 14 countries, as well as the European Economic Area (EEA) [20], and in 2023 the EU chemical legislation REACH expanded this ban to all products containing intentionally added microplastics [21]. The global plastics treaty provides a key opportunity to regulate "problematic and avoidable" microplastics (Part II.3) by establishing a global ban on the production, use in manufacturing, sale, distribution, import or export on microplastics that are "intentionally added" to products. Concerns have been raised about replacing conventional plastics in these products with biodegradable plastic 'alternatives', because it is unlikely these will readily degrade in the natural environment [4,22]. Several natural alternatives to microplastics in PCPs exist including ground nut shells, coconut husk powder, sea salt, coffee, oatmeal, and pumice [23].

Figure 1. Left: Intentionally added microplastics (microbeads) extracted from a cosmetic product (60 times magnification); Top right: microbeads extracted from a range of cosmetics in 2015, shown in small jars in front of the product. Some of these products contain millions of these plastic particles. Bottom left: the same products had no such particles (empty jars) after UK legislation in 2018. Source: University of Plymouth

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