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Focus

Is this your glitter? An overlooked but potentially environmentally-valuable microplastic

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As microplastic pollution evolved to a well-established research field, microplastic scientists started to explore new avenues in the field. Yet, while a multitude of different types of microplastics (microbeads, fibres, fragments) have been well-documented in microplastic literature, our analysis of this literature shows that glitter particles have been overlooked by the field. However, due to the presence of glitter-based research in forensic science, we explore the idea that glitter may have the potential to act as "flag items" - or markers – of a likely source, due to the often complex and individual composition of glitter particles compared to traditional microplastics, such as microbeads. As such, this article demonstrates glitter has insofar been overlooked as a microplastic particle, and demonstrates that glitter may have an important role in explaining microplastic pollution dynamics from source to sink.

1. Why glitter?

Microplastic pollution is an ever-growing environmental concern, with scientific attention expected to peak during the current (2019) to the next couple of years (Halden, 2015). The small size of particles (< 5 mm) combined with an organic composition makes microplastics potentially problematic to aquatic fauna feeding on small particulates, while resistance to degradation and digestion exacerbates the problems microplastics can pose. As such, research has been focused on measuring the accumulation and determining impacts of microplastics in the environment across the globe. This includes research establishing pathways of microplastics from rivers to coasts (Leslie et al., 2017), as well as investigations into the effects microplastic may have on aquatic fauna (Egbeocha et al., 2018). Microplastics have now been described in virtually every place imaginable, including areas outside the natural environment, where research has determined their presence in food products for human consumption including the notable presence of microplastics in bottled water (Oßmann et al., 2018).

Within microplastic sub-categories, one notorious particle is the microbead. These particles are small plastic spheres, manufactured and deliberately included in a number of personal care products, particularly toothpastes and face washes, where particles act as exfoliators (Lei et al., 2017). Recently, a growing weight of public pressure has led to the near-total ban on these particles within rinse-off cosmetic products, a societal movement that has been supported by scientific evidence of microplastic pollution (Rochman et al., 2015). The circumstances surrounding the microbead in cosmetics are relevant to the particle under focus within this article. The glitter particle has not received the same scientific focus as a microplastic pollutant, and it is, instead, general public outlets that are voicing concerns over the glitter microplastic pollutant. This article will examine where glitter can turn up in our modern daily lives, particularly in cases where there is a reasonable expectation of glitter particles entering natural freshwater and marine systems. Additionally, we will examine the scientific literature (or lack thereof) surrounding glitter and postulate why glitter has been overlooked by microplastic researchers. Finally, this article will present the unusual (compared to other microplastics) morphology of glitter, and present why it has, in fact, the potential to be a significant microplastic sub-category due to its possible propensity to be a qualitative indicator particle for potential sources of microplastics into the environment.

2. Presence and environmental pathways for glitter in consumer products

Glitter particles appear in a number of different consumer products, from body paints to nail polish and cosmetics, within art and handcraft products, covering a range of temporal and spatial scales of use (Guerranti et al., 2019). Due to the very small size, dermal oils or even just static electrical force, glitter is adhered to human skin, which often warrants the rinsing of the product with water to remove. This explains

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a direct pathway of glitter to wastewater treatment plants (WWTPs), where, as has been documented for other microplastic types, a proportion is likely to be released in treated effluent water into natural aquatic systems or during overflow events (e.g., Murphy et al., 2016). It is unclear what the removal rate may be for glitter; composition is often predominantly PET (polyethylene terephthalate) and so the best estimates for glitter particles could be considered comparable to other microplastics within the polyester-family. However, as has been discussed by Tagg and Labrenz (2018), microplastics not released in effluents, which instead concentrate in WWTP sludge, may still have pathways into natural aquatic environments.

The use of glitter-based products, generally, could be considered infrequent. However, there are some instances where habitual use could be assumed. Glitter-based nail polishes are one of them (see Young et al., 2018 for examples on nail polish hazardous chemicals), since applications may occur multiple times per week over extended periods. However, based on common removal method (i.e., cotton wool soaked in acetone), there may be less direct input into aquatic environments, landfills being the likely sink (which has distinct environmental concerns that are out of the scope of this article). Glitter-based body paint, although not an everyday use, could constitute a large amount of glitter entering aquatic environments from a single use-case. At times where use-cases are highly increased (i.e., Carnival-type celebrations) the load on WWTPs could be then substantial. There is a growing need for more research into these possible sources and pathways, and given the ever-growing library of microplastic research, the fate of glitter particles, particularly in cosmetics, represents a gap in microplastic research.

3. Glitter in the scientific literature

In comparison to a comprehensive coverage of other types of microplastic particles, it is clear that glitter particles have yet to feature in microplastic papers (Fig. 1). The lack of discussion concerning glitter appears as an important omission in articles about microplastics in cosmetics (e.g., Lei et al., 2017; Napper et al., 2015). For example, a comprehensive IUCN (International Union for the Conservation of Nature) report of the current state of primary microplastics entering the marine environment (Boucher and Friot, 2017) discusses microplastics from a multitude of sources. Microplastics from cosmetic such as microbeads are mentioned multiple times but there is no mention in the report of glitter, although it undoubtedly aligns with the definition of primary microplastics (i.e., those microplastics that reach aquatic or marine environments already in a millimetre size-scale).

The omission of glitter within contexts where it should be expected to have been discussed, or at least mentioned in passing, may be due to a lack of understanding surrounding what glitter is compositionally. Due to the sparkly quality which glitter is utilised to produce, many may expect the composition to be metallic or mineral, since it is true that the light-reflecting quality is often metallic. However, the actual metallic composition is small, being only a fine layer protected by thicker plastic layers (Fig. 2).

However, the lack of environmentally-focused research does not mean that glitter is void of any scientific research. On the contrary, there is a significant collection of research into glitter particles, however this research is concentrated in forensic science (see Supplementary material). This is because glitter particles can act as associative evidence in criminal cases (e.g., Grieve, 1987; Zellner and Quarino, 2009) due to their highly variable multilayered morphology.

4. Uncloaking glitter: particle morphology

The reason glitter can act as associative evidence in forensic science is due to the number of variable characteristics a particle can have, which include those shared by other microplastics such as shape, size, colour, thickness and specific gravity. However, glitter is also composed of a multitude of layers, where polymer surrounds metallised (aluminium) film. Therefore, the number and thickness, as well as the composition of each layer add to the complexity of each particle making them unique. It is this individuality of composition that makes glitter a valuable associative evidence material in forensic science. As such, there is considerable scientific analysis of glitter within this field, particularly using FT-IR analysis, such as synchrotron FT-IR spectroscopy (e.g., Vernoud et al., 2011). Thus, it is clear that glitter is more complex in composition that commonly reported microplastic beads. If, in forensic science, glitter can be characterised and matched to specific products or sources which can help to convict a defendant in criminal court cases, in environmental sciences, microplastic scientists could use glitter to ascertain potential sources, and, for example, hone in on particularly problematic consumer products that constitute most particles to the environment. As yet, this is purely theoretical, but it presents an interesting avenue for microplastic research to progress, since glitter has the potential to be an indicator microparticle for ascertaining microplastic sources.

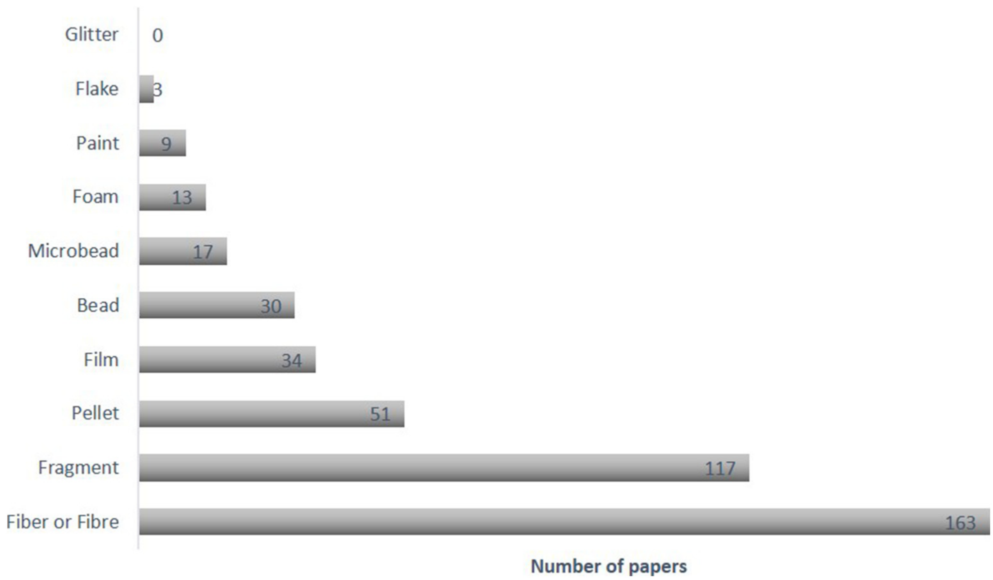

Fig. 1. Bar chart demonstrating the occurrence of different typical microplastic type-definitions within microplastic pollution scientific literature. It is clear that, while bead and microbead are by no means the most common type discussed in the literature, the presence of these particles within the literature is nevertheless demonstrated. Unlike microbeads, glitter, which is also associated with personal care products, does not appear within any microplastic paper.

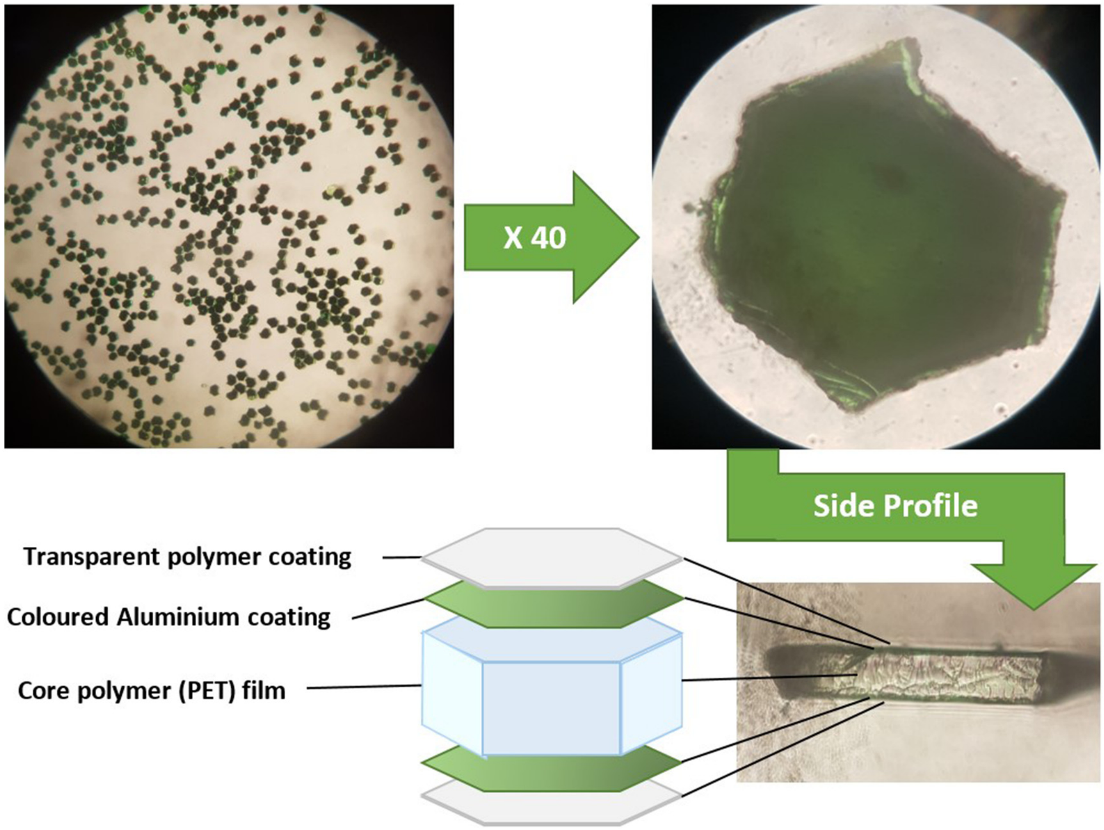

Fig. 2. Demonstration of the composition and morphology of an archetypal unbranded hexagonal glitter particle, typically used in arts and crafts. Top left: × 5 magnification image of glitter particles demonstrating a general uniformity; Top Right: × 40 magnification of a single glitter particle; Bottom Right: × 40 magnification of this glitter particle rotated 90° along the z-axis to visualize the side profile. Clear layers showing the green-metallic coloration and the core clear-polymer layer. Bottom Centre: exploded diagram of a typical glitter particle. Additional visualization and analysis of glitter obtained from nail polish using scanning electron microscopy (SEM) and energy dispersive X-ray (EDX) spectroscopy is presented in the Supplementary material. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

5. Could glitter be the microplastic "flag item"?

"Flag items" are used as a tool in marine litter studies which aim to relate litter contamination to a likely source (Silva et al., 2008). For example, plastic drinking straws act as flag items denoting beach-users as the pollution source, since they are very likely directly discarded onto the beach sand. Conversely, cotton buds are flag items indicative of greywater (household wastewater) sources. For microplastic pollution, it is harder to directly relate a secondary microplastic fragment to the original mesoplastic item, or a fiber to the original garment. Glitter particles, however, have the potential to be directly linked to a specific manufactured product or to the associated WWTP through which they may have travelled, due to their complex and unique morphology. It is still unknown to what proportion and in which places the microplastics in the effluents of particular WWTPs appear. By comparing glitter particles to those found in WWTP sludge, it may be possible to link particular WWTPs to environmental sinks, improving the understanding of the pathways of microplastics after WWTP release.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpolbul.2019.05.068.

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