Microplastics from Road Markings in the United Kingdom

Road Safety Markings Association

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ABOUT US

Established in 1976, the Road Safety Markings Association (RSMA) is the trade association for the road marking sector and is one of the largest specialist trade bodies in the highways industry in the UK. Representing installers, manufacturers and suppliers of road marking products, RSMA members install circa 85% of all road markings in the UK and manufacture circa 90% of all road marking material used on UK roads.

The RSMA Vision: '*Safer roads for all users*'.

The RSMA Mission: '*Delivering safer roads through effective maintenance, skills and technology*'.

This document is Phase #1 of a two phase study. Phase #1 aims to quantify the amount of Thermoplastic, Paint and Cold Plastic marking material sold in the UK between 1 Apr 21 and 31 Mar 22. Phase #2 (which shall be appended at a later date) shall seek to quantify the level of microplastic material as a percentage of the UK total entering the environment during this period.

INTRODUCTION

Plastics are durable polymeric materials which can be shaped and moulded into different forms. Plastic is a versatile material used by numerous industries to produce numerous and varying products all over the world.

The versatility of plastic has led to over-production. While it is a durable material, when exposed to weather, UV light and physical abrasion, plastic starts to deteriorate and, depending where it is deteriorating, can start to fragment into the environment. These fragments can be microscopic in size and this create an environmental challenge – how do we deal with microplastic pollution?

Generally, microplastic parties are defined as being smaller than 5mm, however, many are less than 1mm and some are smaller than 500 µm[1]. Further still, a new category has emerged in recent years – nanoplastics. The term is still under debate, and different studies have set the upper size limit at either 1000 nm or 100 nm[2].

Microplastics (and nanoplastics) can be categorised as either primary or secondary sources. Primary microplastics are intentionally added to certain products, such as in soaps, toothpastes, detergents et al. Since 2019, the addition of primary microplastics to products have been strictly regulated by the EU and in the UK. Secondary microplastics are created when plastics are exposed to physical and chemical factors in nature, leading to their disintegration.

Microplastic particles are omnipresent in the environment. They may be harmful to smaller animals and the food chain. They can be found in soil and may lead to irrigation complications. They can be transported in the air with other dust particles and lead to respiratory issues. The environmental and health concerns remain under investigation.

Microplastic pollution emanates from various sources from across the planet, including highways and road traffic. By far, the largest volume of microplastics from these sources is from tyre wear. Andreas Stohl, from the Norwegian Institute for Air Research found "Roads are a very significant source of microplastics to remote areas, including the oceans," with an average tyre losing 4kg of its mass during its lifetime.[3]

Road markings are ubiquitous yet niche type of industrial coating, poorly defined in literature other than by industry professionals. Consequently, there is a lack of knowledge within the scientific community about the materials used and how they are applied to the road surface which has resulted in flawed information being published.

The contribution to microplastic pollution made by road markings is often overstated due to poor knowledge of the sector and wildly inaccurate assumptions. As road markings are designed to wear off the road surface over time prior to re-application, the aim of this report is to provide an evidence based perspective relating to the formulations and application of road markings and counter previous incorrect assertions that road markings are a significant contributor to microplastic pollution.

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[1] Environmental Microplastic Particles vs. Engineered Plastic Microparticles—A Comparative Review https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8434362/#B25-polymers-13-02881

[2] Current opinion: What is a nanoplastic? https://www.sciencedirect.com/science/article/abs/pii/S0269749117337247

[3] Car tyres are major source of ocean microplastics – study https://www.theguardian.com/environment/2020/jul/14/car-tyres-are-major-source-of-ocean-microplastics-study

TYPES OF ROAD MARKINGS

There are different types of road marking material, but they are all formulated to provide the same function: to improve the safety, efficiency and enforcement of highways and traffic.

Generally, road markings are a formulation of natural aggregates, glass beads, polymers and pigments. The formulations ensure the road markings are durable and reflective. The following definitions of road marking materials are taken from BS EN 1871:2020:

Paints - *liquid product which contains binders, pigments, fillers, solvents and additives, which can be supplied in single or multi-component systems and which, when applied, produces a cohesive film by the process of solvent/water evaporation or the process of solvent/water evaporation and a chemical reaction or coalescence process (in the case of water based product).*

Thermoplastic - *solvent-free marking product which is supplied in block, granular, powder forms or preformed (e.g. as tape), which is heated to a molten state prior to application to road surfaces, and which forms a cohesive film by cooling.*

Cold plastics - *viscous products supplied in multi-component forms (at least one main component and a hardener system), the cohesive film being formed after mixing of all components only by a chemical reaction following which the cold plastic becomes a solid.*

Additionally, road marking materials can be pre-formed, in accordance with BS EN 1790:2013:

Preformed road marking - *factory produced road marking system (or product), in sheet or roll form, capable of being applied to the substrate with adhesive, primer, pressure, heat or a combination of these.*

Tape - *preformed multilayer road marking, capable of adapting itself to the texture of the substrate, which may be precoated with pressure-sensitive adhesive, capable of being stuck to the substrate without heating the material, while the photometric, colorimetric and skid resistance characteristics are not significantly modified during application.*

Preformed cold plastic road marking - *preformed road marking made of cold plastic marking material as defined in EN 1871:2008, applied to the substrate by means of an adhesive, while the photometric, colorimetric and skid resistance characteristics are not significantly modified during application.*

Preformed thermoplastic road marking without drop-on materials - *"pre-beaded" preformed road marking made of thermoplastic marking material as defined in EN 1871:2008, applied to the substrate by heating the material at melting temperature and without addition of any retroreflective and/or anti-skid materials during application.*

Preformed thermoplastic road marking with drop-on materials - *preformed road marking made of thermoplastic road marking material as defined in EN 1871:2008, applied to the substrate by heating the material at melting temperature and with addition of retroreflective and/or anti-skid materials during application.*

UNITED KINGDOM MARKET FOR ROAD MARKINGS

The table below contains estimated percentages of different road marking products sold within the United Kingdom. The percentages are based on data received from road marking material manufactures selling products in to the UK market:

Road marking type	UK market share (%)	Data Confidence Level
Thermoplastic	99.44	VERY HIGH
Cold plastics	0.14	HIGH
Paints	0.41	HIGH

VOLUME OF ROAD MARKING MATERIALS SOLD IN UK FY 21/22

The table below contains estimated volumes of different road marking products sold within the United Kingdom. The figures are based on data received from road marking material manufactures selling products in to the UK market:

Road marking type	Tonnes (1 Apr 2021 – 31 Mar 2022)	Data Confidence Level
Thermoplastic	48,100	HIGH
Cold plastics	69	HIGH
Paints	200	HIGH

MICROPLASTICS IN ROAD MARKING MATERIALS

As stated previously, microplastics can be categorised as either primary or secondary sources; primary microplastics are those which are intentionally added to products and secondary microplastics are created when plastics are exposed to physical and chemical factors, leading to their disintegration.

Certain raw materials found in road markings will be seen as a source of secondary microplastics, though it should be noted at this point that if the resins used in a product are not man-made polymeric material, but rosin-based derived from a natural renewable resource, it can be treated as non-polymeric binders and should be excluded from being considered as a source of microplastics[4].

The table below outlines polymeric materials contained within road markings, some of which are man-made and could be considered as microplastic sources:

Road marking type	Polymer types	Polymer content	Data Confidence Level
Thermoplastic – fossil based	Hydrocarbon	10 - 15%	HIGH
Thermoplastic – bio-based	Rosin	1 - 5%	HIGH
Cold plastics	Methyl Methacrylate	20 - 30%	MEDIUM - HIGH
Paints	Acrylic	10%	MEDIUM - HIGH

Upon reviewing different road marking products and their constituent elements, it was found that all products are capable of releasing polymers over their life-cycle and some of those will be considered as microplastic pollution. But how much microplastic pollution is emitted directly from road markings?

[4] Microplastics and road markings: the role of glass beads and loss estimation https://www.sciencedirect.com/science/article/pii/S1361920921004181

It is very difficult to calculate but correct maintenance of road markings ensures emissions are kept to a minimum.

PRODUCT LIFE CYCLE

Road markings are designed to wear to ensure continuing retroreflectivity. Immediately upon application, the product has glass beads dropped on top to provide initial retroreflection. Additionally, the drop-on beads protect the base-layer from abrasion. As the drop-on beads begin to wear, the intermixed glass beads start to provide retroreflectivity, ensuring the product retains retroreflectivity value. The amount of time it takes for the intermixed beads to become visible is dependent on external factors such as weathering and traffic.

The role of glass beads as a protector to the base-layer, rather than just to provide retroreflectivity value, has been missed in the majority of studies which have claimed road markings are a significant contributor to microplastic pollution.

Road markings should be renewed with a fresh layer of material before the marking loses too much retroreflectivity; if the retroreflectivity of a marking is too low then it is a signal for the road authority that the glass beads have worn away too much. A fresh layer of material would halt abrasions of the base layer before microplastic emissions are quantifiable.

Renewal of markings can continue so long as the thickness of the marking does not exceed the 6mm stipulated in the Traffic Signs and General Directions 2016 (excluding raised rib markings). Upon reaching the thickness threshold, the road marking is removed using mechanical equipment, operated by professionals with minimal release of dust[5].

Standards such as *CS 126 - Inspection and assessment of road markings and road studs*[6] and *RSMA STANSPEC 2022*[7] dictate when road markings shall be first inspected based on the claimed functional life of the product by the manufacturer. CS 126 is a mandatory standard to abide by for road markings and studs on the UK Strategic Road Network, covering motorways and key trunk roads, whereas STANSPEC 2022 is a voluntary standard for local road networks, covering both urban and rural environments. Both standards detail when intervention must be taken, when the retroreflectivity value falls below a certain threshold and/or based upon a visual inspection of the marking.

If road markings are not maintained and not renewed when the intervention levels in CS 126 and STANSPEC 2022 are reached, not only is the safety of the road user compromised, but the glass beads wear and the base-layer may start to degrade. Microplastic pollution from road markings can be minimised through proper maintenance of road marking infrastructure.

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[5] Effectiveness Study of Methods for Removing Temporary Pavement Markings in Roadway Construction Zones https://ascelibrary.org/doi/10.1061/%28ASCE%29CO.1943-7862.0000608

[6] CS 126 - https://www.standardsforhighways.co.uk/dmrb/search/d05b10c6-31b8-4110-a805-d6bd9e4d41d4

[7] RSMA STANSPEC 2022 - https://www.rsma.co.uk/wp-content/uploads/2022/07/20220704-Stanspec-2022-FINAL.pdf

REVIEW OF REPORTS ON ROAD MARKING MICROPLASTICS

Various academic reports concerning microplastic pollution purporting to emanate from road markings have been collated and reviewed. These are listed in the table below.

Report name	Author	Year
Sources of Microplastic Pollution to the Marine Environment (M321)	Sundt et al.	2014
Primary Microplastic Pollution. Measures and Reduction Potentials in Norway (M545)	Sundt et al.	2016
Study to Support the Development of Measures to Combat a Range of Marine Litter Sources	Sherrington et al.	2016
Large microplastic particles in sediments of tributaries of the River Thames, UK – Abundance, sources and methods for effective quantification	Horton et al.	2017
Primary microplastics in the oceans	Boucher and Friot	2017
Investigating Options for Reducing Releases in the Aquatic Environment of Microplastics Emitted by Products	Hann et al.	2018
Emission of primary microplastics in mainland China: Invisible but not negligible	Wang et al.	2019
Investigation of 'microplastics' from brake and tyre wear in road runoff	Barker and Brammer	2020
Microplastics and road markings: the role of glass beads and loss estimation	Burghardt et al.	2022

Sherrington and Wang both report low data reliability, while Hann claims high certainty of their calculations, even though they are based on the same data set. Hann claims that the total microplastic pollution generated from wear of road markings is 94,358 tonnes per year.

Boucher and Friot claim that road markings account for 7% of total microplastic emissions. This report made a fundamental error by assuming that the volume of thermoplastic sold in a specific (non-UK) environment was de facto equal to the volume worn away from the pavement surface (Sundt et al). This is incorrect but this report has been cited repeatedly.

Horton found large, coloured thermoplastic particles in the River Thames (quantity not measured). This was the only report based on a UK study and was the first positive and unequivocal detection of microplastics to originate from road markings. The size of the particles is evidence of the highway authority not maintaining the road marking infrastructure; not only were they permitted to be abraded, but were also completely removed from the road surface. With appropriate maintenance, this would not have occurred.

Barker and Brammer was a study initiated by Highways England (now National Highways) to determine the polluting potential of road runoff both to surface water and groundwater emanating from the strategic road network. However, as a result of COVID-19 restrictions which prevented the field work necessary to undertake road runoff sampling, the scope of the project was changed. The proposals described in the final report have been based on findings from the literature review alone. Therefore, this report claims to amalgamate tyre and road wear particle sources, which includes road markings, and claims they may make-up 40% of microplastics in water environment[8], despite tyre wear being a much larger microplastic contributor. This report also repeats the Boucher and Friot 7% claim.

Burghardt et al. was an international industrial and academic research team, comprising of industry experts and academia across Europe. Two members of the research team were employed by manufacturers and applicators of road markings, however, the support from their respective employers "was limited to providing access to laboratory" (sic).[9] This was the only study which had knowledge of product formulations and applications and can therefore be considered as more accurate than other reports. Burghardt et al. concluded that glass beads, which are an inalienable component of road markings, protect the underlying base-layer, which contains the polymer, from abrasion and that prior assumptions that claimed all applied road markings can be considered as a source of microplastic pollution is incorrect – the microplastic pollution from road markings can be considered to be significantly lower than previously reported.

CHALLENGES

Concerns regarding microplastics have been reported for a number of years. While this report does not seek to prove that road markings are not a contributor, it is clear that the academic reports of yesteryear which claim this are limited in their familiarity of the material and/or application which has resulted in the repetition of flawed claims without a robust scientific or evidential base.

Microplastics from road markings enter the environment via a similar route to other microplastic sources. When road markings are not maintained and renewed and the base-layer becomes exposed, the road marking can become worn through weathering or exposure to traffic. Microplastics can be discharged via road dust; passing vehicles can pick up road dust so the microplastics become airborne and settle nearby or on the vehicle body and then transferred elsewhere. Microplastics can be washed off vehicles and enter bodies of water or soil via road run-off or enter these environments simply through rain water leaving the highway. It is a challenge to find a harmonised sampling and analysis method where the source of the material can be defined for the different environmental matrices.

To identify a standardised method for sampling and sample preparation is difficult. All matrices have different physical and chemical properties. Some are cleaner, such as drinking water, which allows for target particles to be accessed more easily and the samples require less preparations. Other matrices, such as soil or sediment, require more thorough cleaning and extensive preparations. The challenges to achieve a harmonised methodology is to reduce particle loss during preparation as well as reduce cost to make it more accessible.

Samples are usually analysed by stereomicroscope, with Fourier-transformation spectroscopy (FTIR), or gas chromatography mass-spectrometry (usually pyrolysis GC-MS (py-GCMS)). Using a stereomicroscope is usually the most readily available. Its execution does not require highly trained operators, however, the reported results rely on subjective assumptions. The FTIR analysis method is both time-consuming and requires specialist operators; it reports in particle numbers which is usually paired with the sample volume. The py-GCMS method is faster, but still requires trained professionals to operate; this method gives results in mass which is paired with the volume of the taken sample. Additionally, there are ongoing developments which will further increase the challenge of finding a

[8] Investigation of 'microplastics' from brake and tyre wear in road runoff https://s3.eu-west-2.amazonaws.com/assets.highwaysengland.co.uk/Knowledge+Compendium/Investigation+of+microplastics+from+brake+and+tyre+wear+in+road+runoff.pdf

[9] Microplastics and road markings: the role of glass beads and loss estimation https://www.sciencedirect.com/science/article/pii/S1361920921004181#coi005

scientific consensus on reporting methods. When harmonisation of scientific methods finally occurs, the uncertainty surrounding assumptions made on the source and the emitted microplastic volume will be reduced.

The human health effects of microplastics remains far from understood and still only theorised. Previous research such as Campanele et al.[10] concludes that human intake of microplastics is now quite evident but their effects are not yet well known. The trend in the legislative and scientific community appears to be that we must raise awareness of the issue, but concurrently, the problem must be understood better.

The final challenge relates specifically to road markings. Knowledge of road markings and their applications must be considered in any future reports which seek to include them in relation to microplastics. Additionally, highway authorities must ensure that road markings are adequately maintained and renewed frequently to improve road safety as well as limit road marking disintegration before microplastics from road markings reach the environment.

CONCLUSION

This report concedes road markings can be a contributor to microplastic pollution where man-made polymeric material is used and the road markings are not maintained and renewed frequently. They are safety-critical infrastructure allowing for safe use of highways and of paramount importance to future autonomous vehicles, therefore, maintenance of road markings is of paramount importance. Road marking contribution to microplastic pollution appears to be very significantly less than stated in some academic papers and to continue to perpetuate the myth by repeatedly using them as source data for 'new' studies is intellectually moribund. Microplastic pollution is potentially a threat to human health, but the insignificant volume contributed by road markings in comparison to other industries, should not be the focus, especially when there is a lack of consensus regarding methodology and analysis.

[10] A Detailed Review Study on Potential Effects of Microplastics and Additives of Concern on Human Health https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7068600/