Comprehensive Chemical Profiling of Potentially Hazardous Leachable Additives in Synthetic Rubber Surfacing Microplastics

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Overview

➢ The composition of leachable additives from rubber surfacing microplastics were characterized using LC-ESI-MS, followed by an evaluation of their potential hazards using both plastic additive and toxicity databases.

➢ Among the 54 ethanol-leachable chemicals identified, 13 were categorized as rubber surfacing additives, including four phthalate/adipate plasticizers, three phosphate flame retardants, three acyl amides, a rubber vulcanizer, a stabilizer, and a urethane polymerization catalyst.

➢ Three of the identified rubber surfacing additives, dicyclohexylamine (stabilizer), dicyclohexylcarbodiimide (catalyst), and mercaptobenzotriazole (vulcanizer), have been reported to have toxic effects on human.

Introduction

➢ Rubber surfacing, commonly used in outdoor sports facilities and children's playgrounds, can release a substantial amount of microplastics (MPs) into the soil near residential areas.

➢ Rubber surfacing contains various types of organic additives and heavy metals, which can leach out of the rubber and contaminate the soil. For example, an investigation of heavy metal content in rubber surfacing in 23 sports facilities in South Korea found up to 38,800 ppm of lead contamination [1].

➢ A recent study by our team found that the leachable additives of MPs can significantly contribute to their soil toxicity [2]. Other studies have also found that the leachable additives of tire MPs can be harmful to the environment [3], but no research has been done on the leachable additives of rubber surfacing MPs.

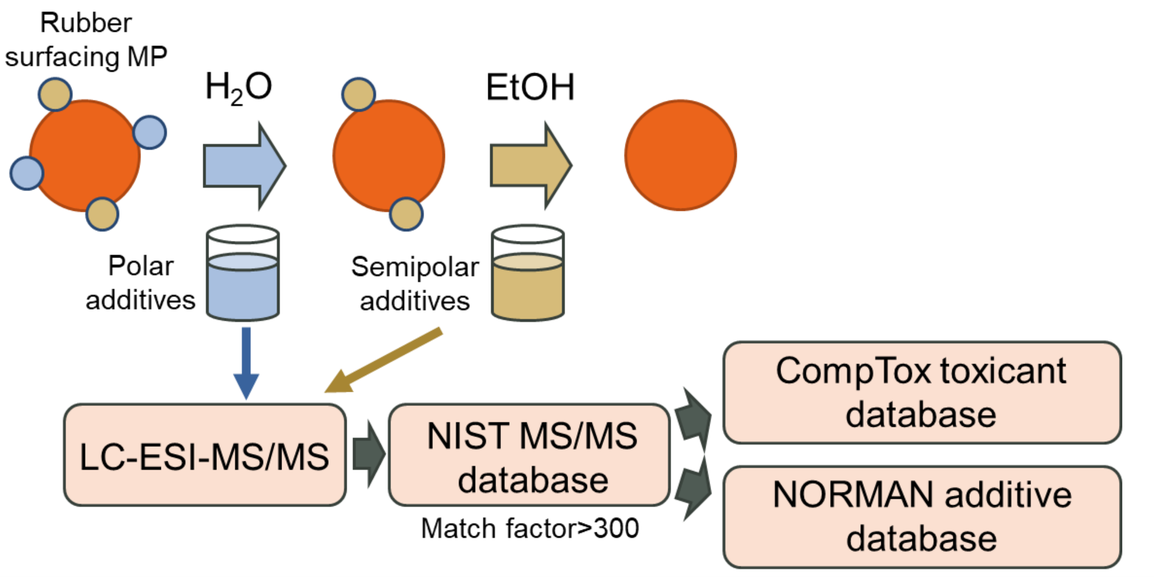
➢ This study conducted a chemical profiling of leachable additives in rubber surfacing MPs using LC-ESI-MS.

Experimental

1. Preparation of rubber surfacing MPs and FT-IR analysis

Sample	Type	Composition	Vendor
RP1	Rubber chip	Ethylene propylene diene monomer (EPDM)+polyurethane (PU)	Roadcape
RP2	Rubber mat	EPDM+PU	Jinwoo Industry
RP3	Rubber mat	EPDM+PU	Changjo Development

2. Chemical profiling of leachable additives using ESI-MS



Results & Discussion

1. Spectroscopic characterization of rubber surfacing MP

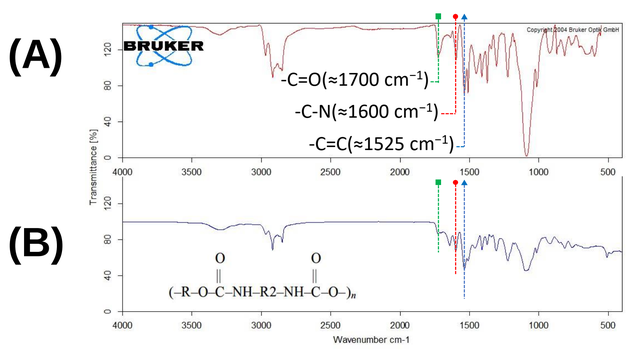


Figure 1. ATR-FT-IR spectra of (A) rubber surfacing MP and (B) polyurethane rubber standard.

➢ The sample spectrum of rubber surfacing MP shows a good agreement with a reference spectrum of polyurethane (cosine score=0.913).

Results & Discussion

2. Identification of toxic additives of rubber surfacing MPs

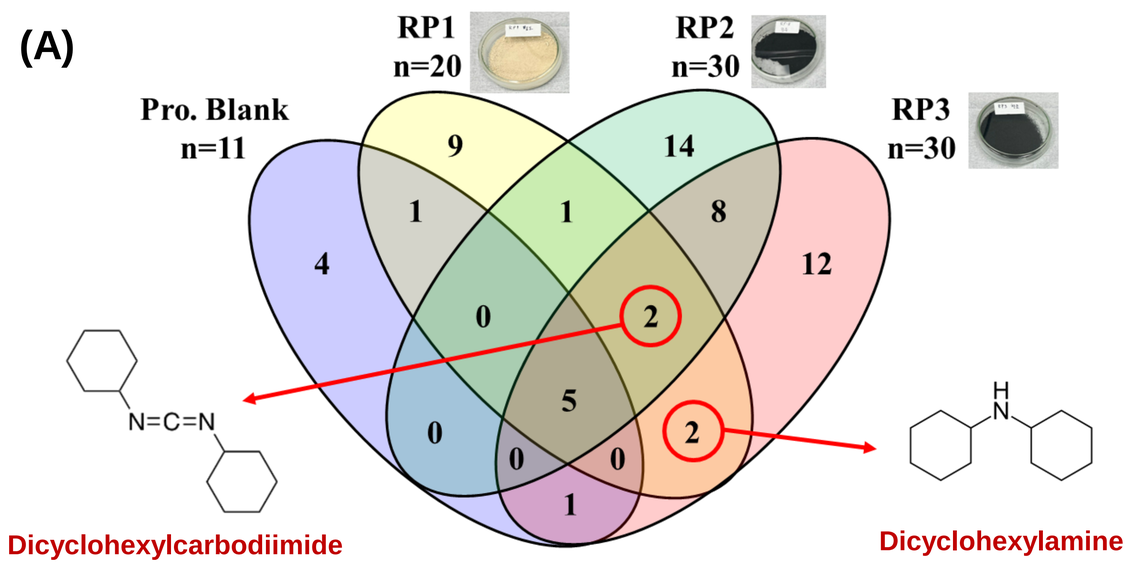


Figure 2. Venn diagram of the identified plastic additives in ethanol leachate from rubber surfacing MPs using ESI-MS in (A) positive and (B) negative modes.

➢ Out of the **73** identified additives, **13** were classified as rubber surfacing additives present in the NORMAN database. **Three** of these additives were reported to be significantly toxic in the CompTox database.

Table 1. List of three toxic rubber additives identified in the ethanol leachate of rubber surfacing MPs.

Compound name	Use	Toxicity
Dicyclohexylcarbodiimide	stabilizing agent	Neurotoxin, acute toxicity-dermal/inhalation
Dicyclohexylaimine	PU catalyst	Corrosive, very toxic to aquatic life
Mercaptobenzothiazole	Rubber vulcanizer	Carcinogen (2A), Cause allergic dermatitis

➢ Among the other additives are phthalates and phosphate flame retardants, both of which are plastic additives known to cause endocrine disruption.

Conclusions

➢ Rubber surfacing MPs contain toxic leachable additives.

➢ A quantitative analysis of the toxic additives in leachates from rubber surfacing MPs and validation of their toxicity using reference standard material will be performed to assess the hazard of leachable additives in rubber surfacing MPs.

References

[1] J. Park *et al.*, Risk Assessment of Pb and DEHP in Elastic Paving Materials of an Outdoor Basketball Court, *J Environ Anal Health Toxicol. 19-26, 2020*

[2] S. Kim et al., Effects of Different Microplastics on Nematodes in the Soil Environment: Tracking the Extractable Additives Using an Ecotoxicological Approach, Environ. Sci. Technol. 2020, 54, 21, 13868–13878

[3] Z. Tian et al., A ubiquitous tire rubber–derived chemical induces acute mortality in coho salmon.Science 371,185-189(2021).

Acknowledgements

▪ This work was supported by National Research Funding (NRF), Republic of Korea (NRF-2022R1A2C200595512).)