Net4mPlastic project

Activity 4.2

D 4.2.3. - Recycling method for collected unsorted microplastic

June, 2021

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1 Introduction

A recycling technology for unsorted microplastics, based on a patent pending method [1], was tested. The method was validated for the use as recycling methof for sample plastic waste. The output is a sustainable foam with interesting thermal and acoustic insulating properties.

2 Materials and methods

Sustainable foam was produced using a bio-polymer matrix (alginate) incorporating waste plastic powder. The foaming method utilized is a low-temperature, blowing agent-free technique.

Plastics from industrial and domestic waste, namely polyethylene terephthalate from bottles and rigid foams, and rigid and expanded polystyrene, were chosen as representative of the microplastics most commonly found in the marine environment. Waste was mechanically grinded, obtaining particle with size lower than 5 mm (so they could be defined "microplastics").

Foams from alginate (a polysaccharide from brown algae) with interesting thermal and acoustic properties (due to their open porous structures) were previously developed and tested with different non-recyclable waste (glass fiber reinforced composites, thermoset resins etc) [2].

The alginate is a linear anionic polysaccharide extracted from brown algae that is already widely known for its suitability as biocompatible scaffold. Sodium alginate consists of two monomeric units, β-d-mannuronate (M) and α-l-guluronate (G).

An interesting property of sodium alginate is its ability to cross-link with bivalent cations to form a rigid "egg-box" structure. It is therefore possible to produce porous structures with very good properties using this natural low cost material.

Foam production was carried out via a sol-gel process, according to a pending patent procedure [1]. Alginic acid sodium salt from brown algae (medium viscosity), glycerol (≥99.5%), D-gluconic acid δ-lactone (GDL, ≥99.0%) and calcium carbonate ($CaCO_3$, 98%) necessary for the sol-gel process were purchased from Sigma Aldrich. Briefly, the alginate was mixed with water, plastics, $CaCO_3$ and GDL. The alginate concentration was experimentally optimized in the range 1.4–2.0% (weight/volume).; lower alginate values did not ensure sufficient viscosity to suspend microplastic particles, while higher alginate concentrations resulted in excessive slurry viscosity. After mixing, the mixture was then poured into Petri dishes (used as sample holders).

A three-dimensional porous hydrogel network is then formed after the Ca^{+2} ions - slowly released from $CaCO_3$ - crosslink with the G-blocks of the polysaccharide; the pH of the solution gradually decreased due to GDL hydrolysis in water.

The principle of this synthesis route is based on the initial formation of a three-dimensional porous hydrogel network. This structure is then preserved by freeze-drying, a process that eliminates liquid water and prevents the consequent collapse of pores. Hence, samples were then frozen at -20°C for 12 h and finally freeze-dried to remove water by sublimation, leaving a porous structure.

3 Results

Results demonstrates the possibility to use microplastics as filler in this foamy material; there are evidence of good acoustic and thermal insulation properties. Microplastic content and type can be varied to customize tha final foam properties. Some sample foams obtained with this method are shown in Fig. 1. For further results and details, see ref. [3]

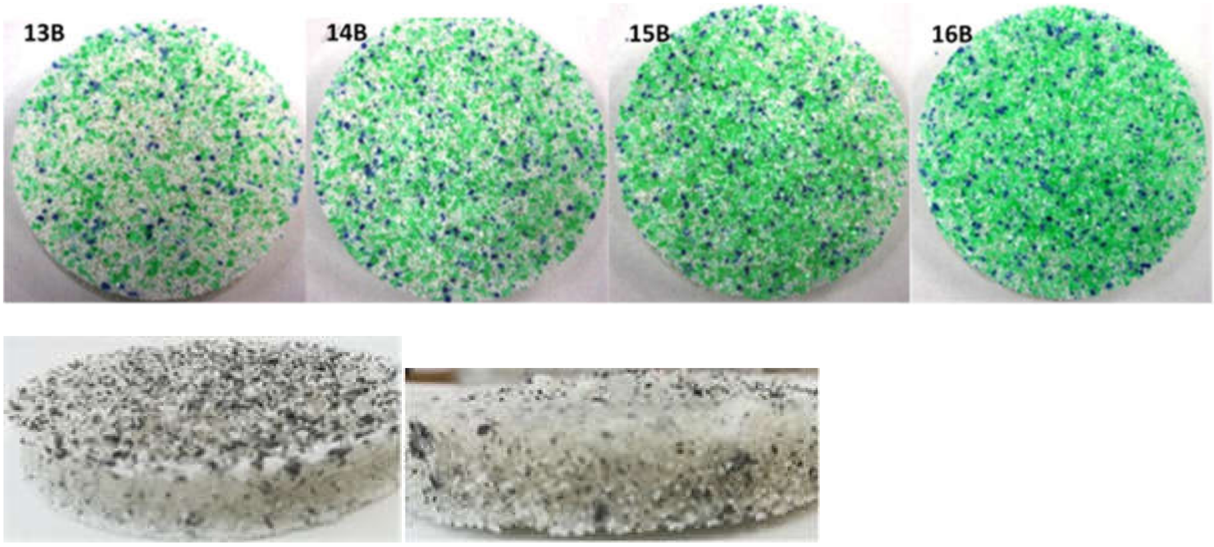

Fig.1: sample foams obtained with alginate matrix and microplastics

References

(1) M. Caniato, A. Travan, Patent EP16425023.5 , “Method For Recycling Waste Material”

(2) “Innovative thermal and acoustic insulation foam from recycled waste glass powder” J. of Cleaner Prod. 165, 1306 (2017)

(3) "Acoustic and thermal characterization of a novel sustainable material incorporating recycled microplastic waste”, Sustainable Materials and Technologies 28, e00274 (2021)