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# A straightforward method for measuring the range of apparent density of microplastics

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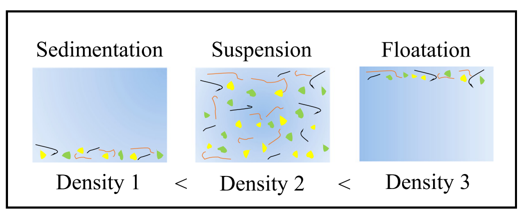
## HIGHLIGHTS

- Bases of ethanol, ultrapure water and saturated NaI are optimal for the density gradient solutions.
- Density gradient solutions are easy to be prepared in a density range of 0.8–1.8 g/cm$^3$.
- Density gradient solutions are feasible to measure the apparent density of microplastics.

## GRAPHICAL ABSTRACT

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## ABSTRACT

Density of microplastics has been regarded as the primary property that affect the distribution and bioavailability of microplastics in the water column. For measuring the density of microplastis, we developed a simple and rapid method based on density gradient solutions. In this study, we tested four solvents to make the density gradient solutions, i.e., ethanol (0.8 g/cm$^3$), ultrapure water (1.0 g/cm$^3$), saturated NaI (1.8 g/cm$^3$) and $ZnCl_2$ (1.8 g/cm$^3$). Density of microplastics was measured via observing the float or sink status in the density gradient solutions. We found that density gradient solutions made from $ZnCl_2$ had a larger uncertainty in measuring density than that from NaI, most likely due to a higher surface tension of $ZnCl_2$ solution. Solutions made from ethanol, ultrapure water, and NaI showed consistent density results with listed densities of commercial products, indicating that these density gradient solutions were suitable for measuring microplastics with a density range of 0.8–1.8 g/cm$^3$.



## 1. Introduction

Microplastic is an umbrella term that covers particles in varies physical and chemical properties, such as density, shape, size and polymer type (Lambert et al., 2017). Studies have demonstrated that certain properties, such as shape and polymer type, play important roles in the uptake of microplastics in aquatic organisms (Graham and Thompson, 2009; Gray and Weinstein, 2017). Therefore, physical and chemical properties of microplastics should be well characterized to explore the association between microplastic exposure and toxic effects in organisms (Andrady, 2017; Pottoff et al., 2017).

As an important physical parameter, density of microplastics invariably determines the distribution and bioavailability of microplastics in the water column (Wang et al., 2016). The positively buoyant plastics (with a density less than water), such as polyethylene (PE) and polypropylene (PP), share the upper water column and those plastics get available to zooplanktons, planktivores and filter feeders (Rochman et al., 2014; Li et al., 2016; Qu et al., 2018). Detritivores, benthic suspension and deposit feeders inhabiting benthos are likely to encounter negatively buoyant plastics, such as polyvinyl chloride (PVC) and nylon (Browne et al., 2013; Wright et al., 2013). Densities of plastics are not

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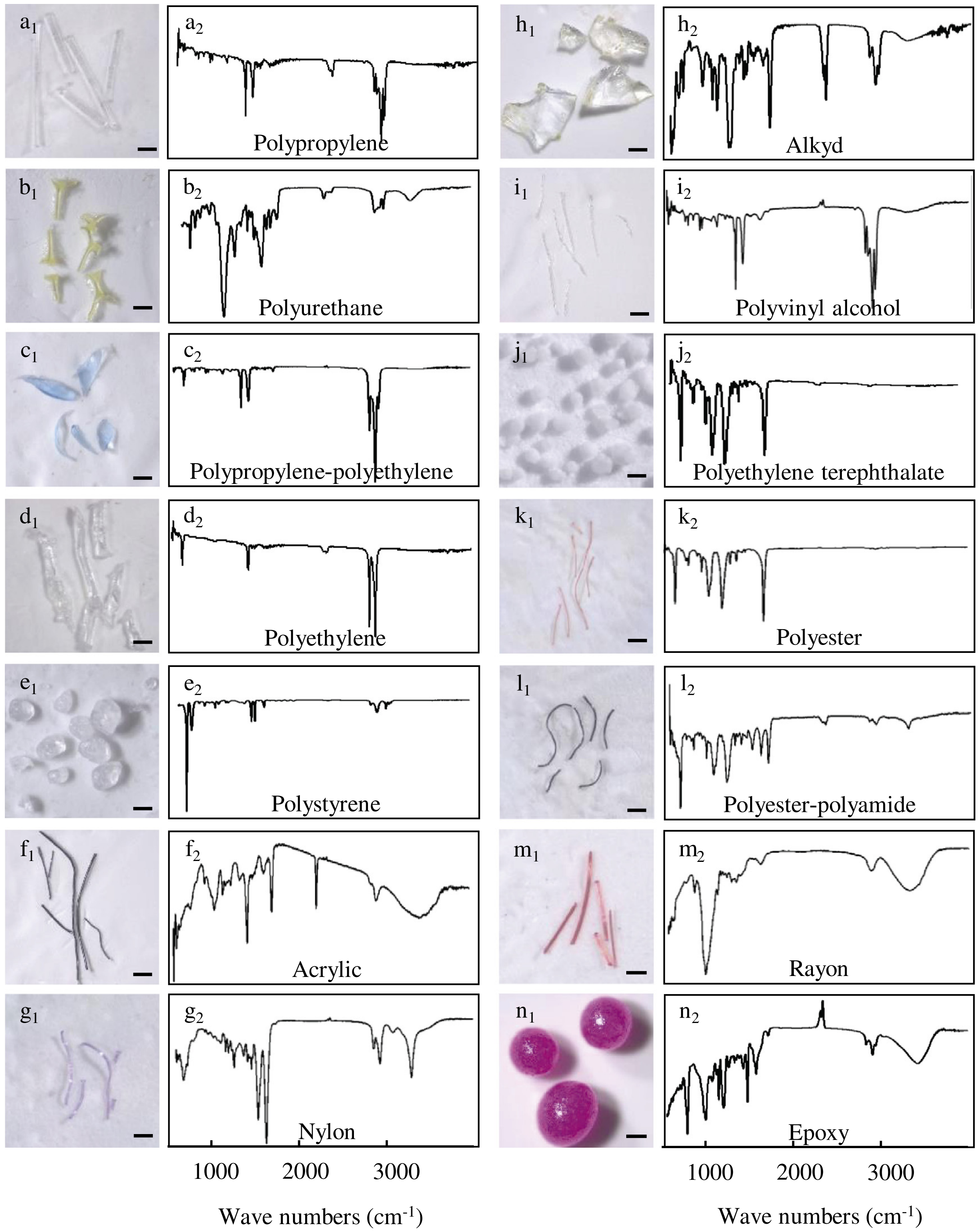


**Fig. 1.** Microplastics ($a_1$-$n_1$) prepared from the original commercial plastic products were identified using μ-FT-IR ($a_2$-$n_2$). Scale bar = 200 μm.

always constant actually. Some additives and modification, as well as voids produced during the compounding and processing of plastic will result in significant changes in the density (Rani et al., 2017). For instance, density of PE increases from 0.92 to 1.28 g/cm$^3$ by additives introduction, which influence the ability to float or sink in water (Anon, 1988).

Although the densities of plastics can be measured based on the American Society for Testing and Materials (ASTM D792), the

**Table 1**
Formula of density gradient solutions (20 mL) in each density from 0.8 to 1.8 g/cm$^3$, using the bases of ethanol (0.8 g/cm$^3$), ultrapure water (1.0 g/cm$^3$), NaI or $ZnCl_2$ (1.8 g/cm$^3$). '–', none.

| Volume (mL/mL) | Density gradient solutions (g/cm$^3$) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 |
| Ethanol/water | 20/0 | 8/12 | 0/20 | – | – | – | – | – | – | – | – |
| NaI/water | – | – | – | 3/17 | 5/15 | 7/13 | 9/11 | 11/9 | 15/5 | 17/3 | 20/0 |
| $ZnCl_2$/water | – | – | – | 2/18 | 5/15 | 7/13 | 10/10 | 12/8 | 15/5 | 18/2 | 20/0 |