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Applying Miniaturized near Infrared Technology for Commingled and Microplastic Waste Analysis

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Abstract : Degradation of the aquatic environment by plastic litter, especially microplastics (MPs), i.e., any water-insoluble solid plastic particle with the longest dimension in the range 1µm and 1000 µm (=1 mm) size, is an unfortunate indication of the advancement of the Anthropocene age on Earth. Microplastics formed due to natural weathering processes are termed as secondary microplastics, while when these are synthesized in industries, they are called primary microplastics. Their presence from the highest peaks to the deepest points in oceans explored and their resistance to biological and chemical decay has adversely affected the environment, especially marine life. Even though the presence of MPs in the marine environment is well-reported, a legitimate and authentic analytical technique to sample, analyze, and quantify the MPs is still under progress and testing stages. Among the characterization techniques, vibrational spectroscopic techniques are largely adopted in the field of polymers. And the ongoing miniaturization of these methods is on the way to revolutionize the plastic recycling industry. In this scenario, the capability and the feasibility of a miniaturized near-infrared (MicroNIR) spectroscopy combined with chemometrics tools for qualitative and quantitative analysis of urban plastic waste collected from a recycling plant and microplastic mixture fragmented in the lab were investigated. Based on the Resin Identification Code, 250 plastic samples were used for macroplastic analysis and to set up a library of polymers. Subsequently, MicroNIR spectra were analysed through the application of multivariate modelling. Principal Components Analysis (PCA) was used as an unsupervised tool to find trends within the data. After the exploratory PCA analysis, a supervised classification tool was applied in order to distinguish the different plastic classes, and a database containing the NIR spectra of polymers was made. For the microplastic analysis, the three most abundant polymers in the plastic litter, PE, PP, PS, were mechanically fragmented in the laboratory to micron size. The distinctive arrangement of blends of these three microplastics was prepared in line with a designed ternary composition plot. After the PCA exploratory analysis, a quantitative model Partial Least Squares Regression (PLSR) allowed to predict the percentage of microplastics in the mixtures. With a complete dataset of 63 compositions, PLS was calibrated with 42 data-points. The model was used to predict the composition of 21 unknown mixtures of the test set. The advantage of the consolidated NIR Chemometric approach lies in the quick evaluation of whether the sample is macro or micro, contaminated, coloured or not, and with no sample pre-treatment. The technique can be utilized with bigger example volumes and even considers an on-site evaluation and in this manner satisfies the need for a high-throughput strategy.

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