A Novel Low-Cost MOF-based Microplastic Sensor

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Introduction to MOFs and Microplastics:

Microplastics are a concern in today's world because they can be digested or inhaled by humans and have been linked to health issues like cellular stress and possibly inflammation. Although microplastics have an impact on humans, they also affect the world environmentally. For example, microplastics accumulate in environments affecting an organism's food webs, and also digested and accumulated in their bodies. The process of the degradation and material of plastics leading to microplastics and nanoplastics makes them difficult to reduce in our world. MOFs, or metal-organic frameworks are made from metal atoms linked together by organic molecules to form an organized and repeating structure. This structure has emerged as an extensive class of crystalline materials and creates a huge amount of empty internal space and a very large surface area compared to their size. MOFs are especially useful for clean-up applications, such as storage gases like hydrogen and methane, and for separating or capturing specific chemicals. They can be used in filters, thin-film devices, chemical reactions and other technologies. Overall, MOFs are important because they combine chemistry and applications in biomedicine. Additionally, MOFs are a valuable resource for new and current researchers in the field alike.

MOFs interact with microplastics by first attaching to their surface, which brings the plastic chains into close contact with reactive metal sites on the MOF. Depending on the MOF, these metal sites either catalyze bond breaking or make highly reactive species that attack its polymer chains. Due to this, it causes different bondings like strong carbon-carbon or carbon-oxygen bonds which break long plastic chains into smaller molecules like monomers or oxidized fragments, which are smaller pieces of a larger molecule. However, sometimes light or electrical energy can potentially activate a MOF, which further proceeds chain breakdown through chemical reactions. MOFs are effective because of their crystalline structure which allows many active metal sites to be displayed. Due to this, it can have more contact with microplastics and result in speeding up reactions. Their chemical structure can be bonded to specific plastics such as PET, PS, or PVC. MOF's can degrade microplastics under mild conditions and produce less toxins during the process and make them a more efficient way for microplastic repair.

Problem trying to be solved:

People detect microplastics by using both visual and analytical usage. For instance, light microscopy and fluorescent dyes, like Nile Red, are common because they're simple and cheap. However, microscopes can often miss non-plastics which creates false information in their research. Additionally, more advanced tools include raman spectroscopy which chemically demonstrates polymers and can work well. However, occasionally, Raman can be slow, expensive, and a slight struggle with tiny particles or samples that may contain lots of background material. Although thermal methods seem ideal, like GC-MS which can measure polymer mass, they can destroy the sample which is expensive to replace. Many researchers and scientists combine several tools and techniques to balance cost, quality, and size. We can use the fact that MOFS degrade microplastics + Nile Red to detect microplastics by concentration (a lot of microplastics -> Nile red is brighter). We can use raspberry pi to detect the color. MOF is not only a detection tool, but mainly as a material to capture or break down microplastics. They have very high surface areas and chemistry which can damage plastic pieces more effectively than any other materials. Although MOFs are powerful in lab tests, they aren't cheap to make- meaning they are more effective than cheap right now.

Methods / Progress:

The experiment will use a selected MOF that can absorb and potentially degrade common microplastics, like PET, PS , or Nile Red dyes with the Raspberry pi camera module. Microplastic contamination will be mixed with MOFs to allow pictures and capture molecule degradation. So far, I did background research on microplastics and coded sensors and cameras on the raspberry pi. I am still working on finding a mentor regarding MOF collaboration as this is required to do in a lab. The expected results if everything goes well, samples with a higher concentration of microplastics will show more fluorescence signals that can be measured by raspberry pi. The MOF will hopefully improve detection by concentrating and breaking down plastics.

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