Developing a Rapid, Colorimetric Metal Organic Framework (MOF) for Airborne Silica and Uranium Detection: A Novel Approach to Pollutant Monitoring and Health Risk Assessment in Indigenous Communities for Sjogren's Syndrome

Poddar, Siyaa (School: Arizona College Prep High School)

Environmental exposure to airborne silica and uranium, pollutants from uranium mining, has disproportionately increased the prevalence of the autoimmune disease Sjögren's Syndrome (SS) in Native American and mining communities. These exposures trigger immune dysregulation and systemic organ failure, often compounded by delayed diagnosis due to variable symptoms, unreliable biomarkers, and a lack of accessible detection tools. Existing pollutant detection methods are cost-prohibitive and lab-dependent, contributing to SS diagnostic delays averaging over six years, with over 50% of cases remaining undiagnosed. To address this, RADAR was developed: a novel solid-substrate colorimetric material composed of Cu-BTC, a high-surface-area, porous metal-organic framework (MOF), embedded in a polyvinyl alcohol matrix and functionalized with reagents, Alizarin Red S and Ammonium Molybdate, for uranium and silica detection. Films were synthesized at 5 functionalization levels (20–100%) and exposed to controlled pollutant concentrations. Upon 15 minutes of exposure, the films undergo visible color shifts. sRGB values of the films were converted to transmittance via 1931 Chromaticity normalization. Statistically significant detection was observed at 100% functionalization, with limits of detection of 0.1 mg/m³ for uranium and 5 µg/m³ for silica and signal-to-noise ratios of 5.25 and 3.79, respectively. Shapiro-Wilk tests ($p > 0.05$) validated the regression models. Structural analysis showed increased surface area ($p < 0.05$) without pore collapse ($p > 0.05$), preserving analyte diffusion. RADAR provides an affordable, interpretable tool for early environmental screening and can help reduce diagnostic delays in underserved communities.

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