Exploring Photoluminescent Self-Assembled Monolayers on Commercial Glass for Biomedical Detection: A Promising Approach

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Exhaled breath, comprising gases, Volatile Organic Compounds (VOCs), and aqueous microdroplets, serves as a critical matrix for detecting lung diseases, including Covid-19. During the onset or resolution of a disease, biochemical processes in the body emit gases and VOCs, which can traverse from the bloodstream to the lung alveoli and subsequently be detected in exhaled breath. Gas chromatography plays a crucial role in this domain due to its capacity to identify, separate, and quantify trace-level gases. However, traditional gas chromatography systems are bulky, lack real-time detection capabilities, and are not easily adaptable to diverse environments.
Therefore, this project aims to develop an optical platform on glassy systems by employing a strategy of chemical functionalization of Self-Assembled Monolayers (SAMs) for the immobilization of advanced photoluminescent materials, including Lanthanide Complexes and perovskites.
The synthesis of $3NH_4[Ln(PMIDA)_2(H_2O)]$ (Ln=Tb(III) and Eu(III); PMIDA=desprotonated N-(Phosphonomethyl)iminodiacetic acid) was confirmed via Single X-ray diffraction, High Performance Liquid Chromatography coupled with mass spectrometry (HPLC-UV-MS), and elemental analyses. The unique arrangement of -OH groups of the phosphonate facilitate chemical bonding, thereby allowing the formation of monolayers on the substrate of commercial SiO_2 glass.
Similarly, the lead-free double perovskites $Cs_2AgBi_{0.1}In_{0.9}Cl_6$ and $Cs2AgBi_{0.4}In_{0.6}Cl_6$ were synthesized by the hot injection method. Powder X-ray diffraction, Raman spectroscopy, and Transmission Electron Microscopy verified the synthesis of materials at the nanometer scale.
To assess the viability of the synthesized materials for detecting VOCs, theoretical investigations and experimental photoluminescent analyses were conducted. The results suggest that the observed photoluminescent changes found in $3NH_4[Ln(PMIDA)_2(H_2O)]$ and $Cs_2AgBi_{0.4}In_{0.6}Cl_6$ perovskite in the presence of acetone are attributed to resonance between the density of states of the complex and the target, rather than a direct reactivity between them.
Finally, the functionalization on glass substrates of advanced photoluminescent materials demonstrated the formation of an Optical Platform with potential for Biomedical Compound Sensing. Moreover, there us the possibility of further enhancement of efficiency by incorporating ligands with energy levels resonant with biomarkers.

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