# Advances in the development of special glasses containing rare-earth ions for luminescence thermometry and sensing of volatile organic compounds

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Recent advancements in the development of optical glasses co-doped with lanthanide ions (Ln) have opened new avenues for luminescence thermometry and sensing of volatile organic compounds (VOCs). In this work, we studied the unique tunable properties of different oxyfluoride glasses, focusing on compositions co-doped with $Er^{3+}$/ $Yb^{3+}$ ($NaPO_3$-$AlF_3$-$BaF_2$-$CaF_2$) and $Pr^{3+}$/$Yb^{3+}$ ($LiPO_3$-$YF_3$-$SrF_2$-$CaF_2$). These materials exhibited high performance as luminescent primary thermometers relying on the thermally coupled levels of $Er^{3+}$ and $Pr^{3+}$, with relative thermal sensitivity between 0.3-1.5 % $K^{-1}$ and temperature uncertainty around 0.5 K at a given temperature, making them competitive with existing luminescent thermometers and promising for cost-effective, accurate temperature probes. The prepared glasses demonstrated excellent resistance to crystallization and possess a broad transparency window extending from the UV to the infrared range (300 to 4000 nm). We also explored the influence of Ln concentration, particularly at higher $Yb^{3+}$ content in the $NaPO_3$-$AlF_3$-$BaF_2$-$CaF_2$ composition, showing the potential to tune $Er^{3+}$ emission wavelengths and temperature responses. Additionally, to design multifunctional glass platforms, we combined Ln-MOF with tellurite and fluorotellurite glass compositions for VOCs sensing. The glasses were prepared by conventional melt-quenching method, while the Ln-MOFs were synthesized via microwave-assisted hydrothermal methods, with $EuCl_3$ and 1,3,5-benzene tricarboxylic or 1,2,4,5-benzene tetracarboxylic acids as precursors. The glass pieces were immersed in the reactive medium inside the reactor chamber. This process was also used to functionalize the end of a single-index tellurite optical fiber. The glass@Ln-MOF composites and Ln-MOFs ($[Eu(BTC)]_n$ and $[Eu(B_4C)]_n$) were characterized by XRD, SEM, and photoluminescence (PL). The TZN@[Eu(BTC)] composite and fiber were exposed to different VOCs carried by $N_2$, with PL measurements acquired in real-time at varying concentrations. Notably, in the presence of acetone and dimethylformamide, a 15-fold luminescence enhancement was observed for the $^5D_0 \rightarrow {}^7F_2$ transition of $Eu^{3+}$, exhibiting intense luminescence under UV light and high sensitivity to acetone, hydrocarbons, and dimethylformamide. In summary, this work highlights significant advances in integrating Ln into optical glasses, enhancing luminescence thermometry and chemical sensing. The development of these materials contributes to photonic technologies and sensing applications, offering high stability, tunable optical properties, and straightforward synthesis procedures.

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