## ABSTRACT

The photophysical properties of optical sensors can be altered by binding a specific target analyte to the receptor, resulting in enhancement or quenching in fluorescence signal that helps us to detect and analyze specific target analytes with high sensitivity and selectivity. So, Optical sensors are found in many different fields of application, including metal sensors, pH sensors, biomedical imaging and diagnostics, photovoltaic devices, solar energy conversion, display technologies, etc. Optical sensors have recently received a lot of attention due to their photophysical properties that are sensitive to the understanding of the target analyte interaction.

**Chapter I:** In this chapter, different types of target analytes with their important role and adverse effects in biological and environmental systems have been discussed. Also, a brief discussion on optical sensors, their photophysical properties, and several signaling mechanisms, based on different photophysical processes such as ICT, PET, ESIPT, FRET, paramagnetic fluorescence quenching mechanism, and DFT analysis have been done here to understand the interaction between sensor and target analyte.

**Chapter II:** A simple ratiometric, turn-on chromo-fluorogenic sensor, *(E)-2-((2-hydroxybenzylidiene) amino)-5-nitrophenol* (**HBAN**), has been developed, synthesized, and characterized by several conventional analytical methods. **HBAN** is found to be selective for the sequential detection of $Al^{3+}$ ions and picric acid (PA), respectively, based on the fluorescence „off-on-off" method. A remarkable fluorescence enhancement of **HBAN** is detected at 540 nm upon binding with $Al^{3+}$ ions with visual yellow color fluorescence under a portable 365 nm UV light irradiation. Among the various tested nitroaromatic compounds, PA selectively quenches the fluorescence of the $Al^{3+}$ ions chelated **HBAN** complex. The formation of the complex between **HBAN** and $Al^{3+}$ ions is found to be in a 1:1 stoichiometric ratio and the LOD is found to be nanomolar range. The mechanistic aspects of detecting $Al^{3+}$ ions have been elucidated by different spectroscopic and density functional theoretical analyses. Additionally, a test kit based on paper strips coated with **HBAN** is demonstrated to selectively detect $Al^{3+}$ ions.

**Chapter III:** A phthalimide-decorated novel acid-responsive probe **Z1** is designed and synthesized based on a conjugated donor-acceptor (D-A) subunit. The synthesized probe shows a colorimetric visual change through protonation and deprotonation processes with the addition of acid and base in the non-aqueous medium. A ratiometric UV-visible absorption spectral change is observed with the addition of acid, and the density functional theory investigation supports the experimental findings. A colorimetric paper strip-based experiment has been demonstrated to detect trace amounts of acid and bases in non-aqueous solvents. Furthermore, the overlapping indicator method is explored to estimate acid dissociation constants in the non-aqueous medium. The acid-responsive colorimetric behavior of this probe is fully reversible with the addition of bases, and using this reversible colorimetric response, we have constructed the INHIBIT (INH) and IMPLICATION (IMP) molecular logic gates. The present report

invokes a new avenue for synthesizing several acid-base sensors and estimating the acid dissociation constants of diverse acid-base compounds in the non-aqueous medium.

**Chapter IV:** Detection of fluoride ($F^-$), acetate ($AcO^-$), and cyanide ($CN^-$) anions are vital from the biological and environmental aspects. In the present contributions, we have introduced a simple Salen-type chromogenic sensor, **BEN,** to detect these biologically important anions. Changes in UV-Visible absorption spectra and color of **BEN** solution from very pale yellow to pink color are similar for each of these anions and found to be reversible only in the case of $F^-$ ions in attendance of $HSO_4^-$ ions. Estimated limit of detection of **BEN** solution for detecting $F^-$, $AcO^-$ and $CN^-$ anions are found to be below the micro molar (μM) concentration level. Our fabricated handy paper test kit is suitable for qualitatively naked-eye detection of the anions. An immediate quantitative estimation of these important anions is possible using our **BEN** employing a smart phone, avoiding any costly experimental setup.

**Chapter V:** Extremely toxic G-series nerve agents are used as weapons for mass destruction in wars and terrorist attacks. So, rapid and accurate detection of these dangerous nerve agents is immediately required to save our environment and nation. In this article, we have designed and developed a chromone-coumarin coupled fluorogenic probe **MATC** that can selectively detect sarin gas mimicking diethylchlorophosphate (DCP) with the detection and quantification limit in the nM (nanomolar) range. **MATC** solution with DCP exhibits remarkable fluorescence intensity at wavelength 465 nm displaying bright cyan color photoluminosity under the exposure of 365 nm UV lamp, which is also manifested from the color chromaticity diagram as a result of disruption of excited state intramolecular proton (ESIPT) process due to the phosphorylation process. Straining our probe, **MATC,** on Whatman-41 filter paper, we have also fabricated a paper strips-based test kit for on-the-spot recognition of sarin gas as a movable and displayable photonic device. A dip-stick and dipped-vial-conical-flask experiment has also been demonstrated to recognize and quantify DCP in the vapor phase. The present report demonstrates a complete description of a fluorogenic and specific chemosensor to identify and quantify deadly nerve agents within the stores of analogous organophosphates and inorganic phosphates.

**Chapter VI:** The summary and future scope of present research work have been mentioned in this chapter.