Abstract

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Title: Multi-parameter Detection using Optical Spectroscopy for Monitoring and Control of Biomedical Anomalies, Food Adulteration and Environmental Pollution

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Optical spectroscopy is reported to offer multi-dimensional parameters for the detection of several anomalies ranging from bio-medical, food quality and environmental purity. In the present work, a brief introduction to the different types of spectroscopic methods used in various kinds of biomedical applications, environmental pollution monitoring and food quality assessment applications have been discussed. An overview of spectroscopic techniques, both the dynamical and steady-state, the structural aspects of biologically important systems, fluorescent probes and nanomaterials used in the experiments are also provided. Details of instrumentation, data analysis and experimental procedures involved in this thesis work have been discussed elaborately.

The development and validation of a noninvasive spectroscopic device for bilirubin and hemoglobin estimation in neonates without using any blood samples or chemical reagents at point-of-care in neonatal subjects with high precision and accuracy have been demonstrated. This thesis also demonstrates that the developed device is equipped with machine learning algorithms and can also generate and instantaneously transmit the report to a medical expert through e-mail, text messaging, or mobile apps. A nano-formulation prepared by molecular co-localization of multiple drugs in a nanoscopic delivery vehicle for potential synergistic remediation of multi drug resistant bacteria has also been discussed as an application of optical spectroscopy in bio-medical field. Development of nanomedicine from copper mine tailing waste as a pavement towards circular economy with advanced redox nanotechnology is another topic of discussion of this thesis.

Studies on optical multi-parameter for environmental pollution monitoring have been highlighted in this thesis. An efficient and portable spectroscopic instrument for multiplexed monitoring of acute water toxicity has been developed. The Design, testing, and evaluation are discussed in details. Arsenic is listed as one of the most harmful pollutants in drinking water. An ultrasensitive reagent for ratiometric detection and detoxification of inorganic arsenic III in water and mitochondria has been formulated and its promising performance has been evaluated.

As an application of optical spectroscopy in food quality determination, spectroscopic studies on a natural biomarker for the identification of origin and quality of tea extracts for the development of a portable and field deployable prototype is discussed in this thesis. Simultaneously, interaction of chlorophyll with toxic artificial colorants like malachite green, copper sulphate and sudan red in restricted nanoscopic environment is elaborately studied to explore the key insights on the toxicity from electronic spectroscopy.

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