ABSTRACT

To a certain extent, all processes for energy conversion are associated with the production of toxic by-products such as Carbon monoxide (CO) Oxides of Nitrogen (NOx) and aromatic hydrocarbons. The significant part of Carbon monoxide and Oxides of Nitrogen emissions originates from exhaust of motor vehicles due to their poor maintenance, tremendous increase in their number, and use of outdated vehicles. India is one of the largest automotive manufacturers in the world. Consequently, due to the combustion of fossil fuels, the vehicle pollution has become the cause of major concern. All these pollutants due to their toxicity are harmful not only to human beings but also to plants. It is observed from both the gasoline/petrol or diesel vehicles that the main component of automobile emission causing harm to human and environment is carbon monoxide.

Detection of carbon monoxide plays a vital role for many scientific, household, environmental and industrial applications. As per the Indian government Automotive Norms for pollution checkup, the vehicle has to be taken to a Pollution Under Control (PUC) centre for the measurement of carbon monoxide present in the exhaust gases released from vehicles. There is no in-situ measuring instrument for the detection of Carbon monoxide while the vehicle is on road. The equipment and infrastructure at the Pollution Under Control centres are expensive and uses conventional sensors. As an alternative, Biosensors which have got wide applications in medical field can offer scope for their use in automotive applications.

Biosensors are analytical tools for the analysis of bio-material samples in medical field to gain an understanding of their bio-composition, structure and function by converting a biological response into an electrical signal. The biological recognition element (Sensing Technique) is functionalised with enzyme, antibodies, Deoxyribo
Nucleic Acid (DNA), or cell membrane. The enzyme or Antibodies react with only particular analyte (sample) Antigen only. With this advantage, the selectivity of the biosensor is more and avoids the interference of the other analyte in the sample.

In human beings each haemoglobin group consists of an iron ion held in a heterocyclic ring, known as “Porphyrin”. The porphyrin holds the oxygen in the haemoglobin and carries to the body cells. Further, this porphyrin has affinity for carbon monoxide 200 times greater than its affinity for oxygen. This means that presence of small amount of carbon monoxide reduces the ability of carrying oxygen considerably. Hence porphyrin is considered as coating material in biosensor for the present investigation, and for adsorption of carbon monoxide in engine emission.

Biosensors are usually less expensive and are of miniature in size. With the use of these sensors the instrument may be made as compact and handheld device. Hence, an attempt has been made in the present investigation to fabricate and test the biosensor made out of microcantilevers functionalized with Iron porphyrin and with an aim to develop a handheld device for pollution check-up in automotive vehicles.

This study includes an overview of automotive market in India, general concepts of combustion, Indian pollution norms, all types of gas sensors, biosensors, cantilever sensors and the coating material porphyrin. A review of various works related to the conventional sensor and biosensors is presented.

The experimental set-up, fabricational aspects and instrumentation are comprehensively explained in the thesis. All the components needed for the experimental set-up are supplied by the Centre for Excellence in Nanoelectronics (CEN), Indian Institute of Technology, Bombay, under Indian Nano Users Programme (INUP) except the sensor device. The sensor device made out of SU-8/Carbon Black integrated piezoresistive cantilever is fabricated at Centre for
Excellence in Nanoelectronics (CEN) centre and the process of fabrication is described and readout method is also explained.

The experimentation begins with the flow diagram, wherein, the experiments are carried out in three phases. The phase-I experiments deal with response of carbon monoxide with porphyrin functionalized cantilevers (Biosensor). The response of biosensor is validated. The basic sensitivity characteristics of this biosensor are evaluated and reported in the thesis.

The Carbon Monoxide adsorption with porphyrin is further confirmed using conformation tests such as Fourier Transform Infra Red (FTIR) spectroscopy, Ultraviolet-Visible (UV-Vis) spectroscopy, Atomic Force Microscopy (AFM) in phase-II. Finally, in Phase-III experiments are performed on real engine (Twin Cylinder Diesel Engine) at the department of Mechanical engineering, Srikalahasteeswara Institute of Technology, Srikalahasthi and tested the Biosensor developed at Indian Institute of Technology, Bombay and commercial sensor (TGS 5042). The results are analysed and conclusions are presented. A prototype model for in-situ measurement of carbon monoxide is developed.