CATALYTIC INCINERATION OF VOLATILE ORGANIC COMPOUNDS

by

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Submitted in fulfillment of

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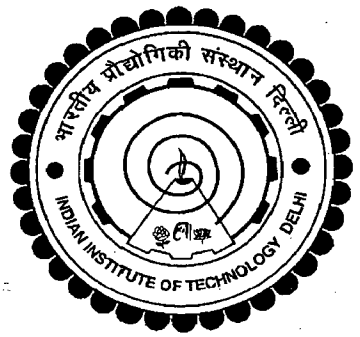

INDIAN INSTITUTE OF TECHNOLOGY DELHI

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DEDICATED

TO

MY PARENTS

CERTIFICATE

This is to certify that the thesis entitled, **"CATALYTIC INCINERATION OF VOLATILE ORGANIC COMPOUNDS"** being submitted by **Mr. P.V.K.K.Varma** to the Indian Institute of Technology, Delhi for the award of Doctor of Philosophy is a record of bonafide research work carried out by him under our guidance and supervision in conformity with the rules and regulations of Indian Institute of Technology Delhi.

The research report and results presented in this thesis have not been submitted, in part or full, to any other university or institute for the award of any degree or diploma.

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(P.V.K.K.VARMA)

ABSTRACT

Enhanced industrial activity and improved standard of living have caused significant increase in quantity of waste generation and its complexity. Volatile Organic Compounds (VOC's) are a major source of such pollutants and have posed a serious threat to environment. Several industrial manufacturing systems produce and release these chemicals, through vents, as unused chemicals in form of disposable pesticides, medicines (beyond their shelf life) and as organic sludge. Most of these chemicals are non biodegradable in nature (refractory type organics). Hence incineration (controlled combustion) is the only technique available for the destruction of such chemicals. In the present study performance of the incineration process under different operating conditions have been evaluated. Further it was aimed to determine conditions for high destruction efficiencies at moderate conditions of temperature and pressure to reduce energy consumption as well as to reduce the formation of secondary air pollutants. Benzene has been taken as the representative of VOC's due to the fact that aromatics predominate the VOC's.

The incineration of benzene and its derivative show that the use of catalyst lowers the temperature of operation by a significant margin from 800°C required for thermal operation to as low as to 250°C for the catalytic process using Pt-CeO_2 catalyst for the high degree of combustion efficicency desired for proper control system i.e., 99.9% as desired. This lowering of temperature facilitates the incineration operation in many important ways. Firstly it reduces the energy consumption of the process, secondly it makes the process system easier to control and install because of simpler material of construction and thirdly it reduces the formation of secondary pollutants like nitrogen

oxides etc. Among the many catalysts studied Pt/Al_2O_3 based ones were found to be most effective. The effectiveness was enhanced by the addition of Rh as a promoter. The loading of Pt in the catalyst had marginal impact in the range of 0.1 to 1%. It was observed that $Pt\text{-}Rh/Al_2O_3$ is the best catalyst among the series of catalysts used for the incineration of benzene as a representative of VOC.

The addition of transition metal oxides like Ceria (CeO_2) to $Pt\text{-}Rh/ Al_2O_3$ further enhanced the reaction to some extent and the temperature for 99.9% combustion was reduced by about 25°C compared with the Pt-Rh catalyst. Further it was also observed that CeO_2 enhanced the stability of the catalyst. The reduction in the catalyst activity even after 100 hours continuous operation was negligible compared to that of other catalysts which showed reduction in the range of 1-2% for the same period of operation. The physical and other tests of the catalyst after prolonged operation showed no change of color or metallic structure for catalysts containing Pt, indicating no deposition of carbon or transformation of metallic structure. However, in case of transition metals similar experiments showed blackening of catalysts.

The experimental data for the non catalytic and catalytic incineration system was used to estimate the kinetic parameters. The results of activation energy and rate parameters compared very well with the published data for incineration of benzene. The catalytic reaction system was found mostly controlled by reaction rate with negligible resistant to pore diffusion and external mass transfer.

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