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Investigation of the Odours Emitted from Chemical Plants by Gas Chromatography-Mass Spectrometry†

V. ARJUNAN‡, S. SUBRAMANIAN‡ and S. MOHAN*
Raman School of Physics, Pondicherry University, Pondicherry-605 014, India
E-mail: s_mohan@lycos.com

Odour escaping from the chemical, dye manufacturing and steel industries are a continual source of complaints by locals of nearly a decade. Although several precautions such as filtering system have been introduced by these industries, noxious smells still escape frequently whenever the filter system is saturated. Since the removal and regeneration of these filter systems is an expensive task, very little is done in this regard. Hence an attempt has been made in the present work to examine the compounds adsorbed on the filters using gas-chromatography with a mass-spectrometer detector. The components identified in the process are hydrocarbons, sulphur containing species, various amines and amides, aldehydes and ketones, aliphatic acids and esters, aliphatic alcohols, aromatic alcohols and phenol.

INTRODUCTION

The economical and industrial activities have greatly expanded all over the world in the last century. The development and economic growth of the modern society has been based on these activities. They have brought several environmental problems such as the pollution of soil, atmosphere, water and food. Many countries and several interested organizations and investigators put a lot of effort in order to minimize this problem.

The industrial pollutants are known to contaminate the abiotic components of the ecosystem and also pose threat to the sustenance of plant and animal kingdoms on the earth. The quantity, quality and toxicity of various pollutants vary with the types of industries; so the pollution profile of different industrial polluting agents is variable.

Air pollution has become one of the most important problems of the entire world. It has been recognised that even trace concentration of atmospheric compounds can have a substantial impact. The greenhouse effects, ozone depletion, acid rain and degradation of human health are related to the increasing concentrations of trace gases and vapours in the atmosphere.

There are several methods to detect trace gases. In the past numerous techniques ranging from chemiluminescence to gas chromatography have been developed and successfully applied to atmospheric monitoring. Some of them

‡Department of Chemistry, Pondicherry Engineering. College, Pondicherry-605 014, India.
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have become standard methods and widely used on a routine basis by environmental institutions and authorities world wide. However, there are several requirements that cannot be fulfilled by conventional dedicated techniques.

The chemical, dye manufacturing and steel industries give rise to considerable odour problems and plants engaged in these industries are a considerable source of complaints by locals. Although, these plants take care of environmental pollution, the odour problem is a perennial one. On the outskirts of Pondicherry-Cuddalore are such plants in the SIPCOT industrial estate which process chemicals, dyes, and steel products. Although several precautions such as filtering system have been introduced by these industries, noxious smell still escapes frequently whenever the filter system is saturated. Since the removal and regeneration of these filter systems is an expensive task, very little is done in this regard. Hence an attempt has been made in the present work to examine the compounds adsorbed on the filters using gas chromatography with a mass spectrometer detector.

There has been much evidence during the past two decades showing that the determination of the noxious odorous compounds is insufficient to evaluate its essentiality, neutrality or toxicity. The low level detection of compounds significant in industrial field poses stringent requirements for analytical systems. Gas chromatography plays a vital role in the analysis of both major and minor components in the evnironment. Gas chromatography is extensively used in the fields of food, flavour and fragrance[1, 2], petroleum and related chemicals[3–6], biological[7], medical[8, 9] and environmental[10–12] applications. The recent advance in the coupling of gas chromatography with mass spectrometer detector is currently the primary tool for the determination of environmental organic, inorganic and organo-metallic contaminants. Advancements in terms of versatility, large dynamic range, sensitivity, precision and field applicability of gas chromatory/mass spectrometry coupling make this technique have its best years still ahead of it. Moreover, the system is on the one hand easy to use and allows the separation and identification of multi compounds and complex mixtures on the other hand. The limitations of the coupling are not related to instrumentation any more but appear on the sample preparation and are related to the elimination of contamination and peak identification.

In many cases, regulatory agencies have specified a "standard" or "accepted" procedure for the analysis of given materials in a given matrix. Environmental Protection Agency (EPA) first specified procedures[13] for monitoring industrial eluents in 1977. Some of the approved methods[14] were amended in 1980. While the initial methods specify the use of packed columns, many of them have been revised for the application of capillary column technology especially the 500 and 8000 series. Methods 601, 602, 603 and 624 are concerned with volatile pollutants[15]. Sampling of volatile organic compounds on solid adsorbents and then analysing by thermal desorption and gas chromatography with mass spectrometer detector is a sensitive and widely used technique. The method 624 requires the use of a mass spectrometer detector to confirm peak identities.

EXPERIMENTAL

The absorbed carbon compounds from the carbon filter bed of various industries were collected. These are desorbed either by agitation in solvents like methylene chloride, acetonitrile or warming and condensing the evolved gases in a liquid nitrogen cold trap. The analysis of the compounds can be accomplished by gas chromatography with a mass spectrometer detector in the ion monitoring mode.

A non-polar 25 m cross linked methyl silicone capillary column is used for separation. The capillary column used allows maximum components to elute in boiling point order. Only very few polar molecules eluted as compared to their boiling points. Thus the interpretation of mass spectral data could be cross-linked against the predicted boiling points.

RESULTS AND DISCUSSION

The typical separation of various odorous compounds emitted from the industries is shown in Fig. 1. Most of the peak identifications were found using an 8 peak automatic library search routine and available spectral data in our

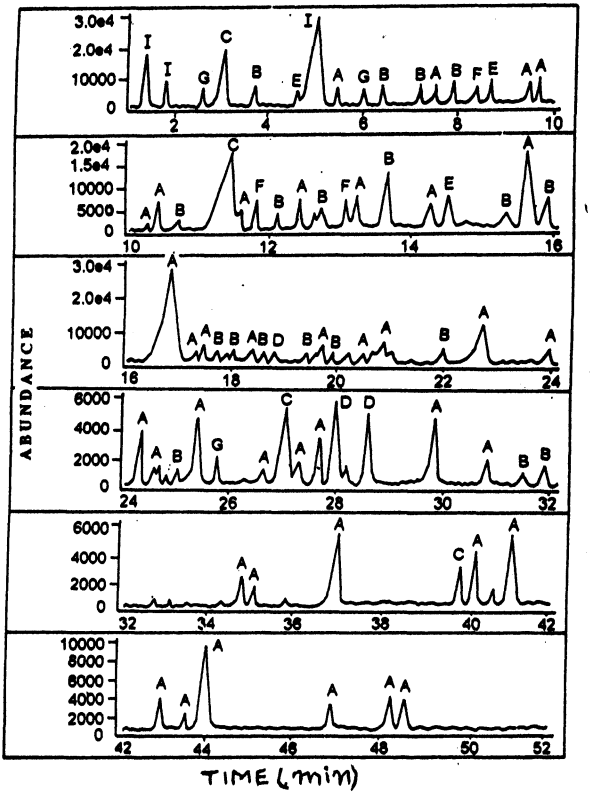

Fig. 1. Total ion current chromatogram of extract from carbon filter bed (b.p. range 60–360°C)

laboratory. The compounds identified so far are aliphatic hydrocarbons up to C_{30} marked as (A), aromatic hydrocarbons marked as (B), the sulphur containing species like alkyl di-sulphides and tri-sulphides and thiophenes marked as (C), various amines and amides marked as (D), aliphatic acids and esters marked as (E), the ketones and aldehdyes marked as (F), aliphatic alcohols marked as (G), aromatic alcohols and phenols marked as (H) and some chlorinated species from the solvents used to degrease the processing plant marked as (I).

Conclusion

The environmental analyst may be concerned with the determination and/or quantification of many different substances in a diversity of environments. With a large number of creative scientists engaged in these analytical activities, it is not surprising to find that our capabilities have progressed rapidly. Fruther, the work was extended to find an alternative method to remove the noxious components of the odour.

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