METHODS OF CONTROLLING HARMFUL GASES, VAPOURS AND DUSTS IN INDUSTRIAL AIR

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The problem of controlling the concentrations of harmful gases, vapours and dusts in industrial air is closely connected with the aims of a separate branch of analytical chemistry, which in the Soviet Union is called " industrial-medicinal chemistry ".

The basic tenet of industrial-medicinal chemistry is that working conditions in industrial establishments should be controlled by means of objective and exact analytical methods.

Systematic research in this field has been carried on in the Soviet Union since the 1920's. Theoretical and practical work on the analysis of industrial air is now being done by a large number of chemists working in research institutions, chemical laboratories of epidemological stations, and in large industrial establishments.

The co-ordinating body is the Central Bureau of Methods which approves new analytical methods and apparatus. It organizes scientific conferences and plans methodical research. As Professor Letavet mentioned in his paper, it would be useless to set standards for the concentration of toxic substances in air without control of the atmosphere.

The establishment of maximum allowable concentrations (M.A.C.'s) enforced by law makes it necessary for industrial-medicinal chemistry to work out and put into practice the most sensitive, selective and reliable methods of analysis, and the problem becomes more difficult as the range of toxic substances extends and the M.A.C.'s are systematically lowered to tenths and hundredths of a μg/l. air. The methods of industrial-medicinal chemistry today allow the determination and control of over 200 toxic substances.

In the study of the atmosphere the method of sampling is of great importance. For most purposes the expiration method is used, but, when short industrial operations are involved and the sample must be taken quickly, the vacuum method is preferred. For the absorption of gases and vapours, liquid and solid absorbents are used. Aerosols are taken up on filter media, cotton-wool, paper and filters made of fine polyvinylchloride fibres. For absorption vessels, we use those in which the absorbing liquid is suspended as a dispersion. Air can be drawn at high speed through such apparatus.

For the determination of microquantities of toxic substances in air we use photometric, polarographic, luminescence, volumetric, spectrophotometric,

and chromatographic analysis. Of particularly wide application are photometric methods using highly sensitive colour reactions, which have been worked out by Chugaev, Komarovskii, Kuznetsov, Babko, Alimarin, Korenman in the Soviet Union, and Daniel, Gage, Fujiwaa, and others, abroad. The following are some examples of such highly sensitive reactions:

(i) the reaction of hydrazine with *p*-dimethylaminobenzaldehyde, sensitivity: 0·0001 mg;

(ii) the reaction of formaldehyde with chromotropic acid, sensitivity: 0·0005 mg;

(iii) the reaction of sulphur dioxide with Schiff's reagent, sensitivity: 0·0001 mg;

(iv) for mercury: the formation of iodine–mercury–copper complex, sensitivity: 0·0003 mg;

(v) for phosphoric acid, formation of the blue phosphomolybdic complex, sensitivity: 0·00025 mg.

The reactions which are the basis of many of these methods are highly selective. Thus, by the quinoline reaction it is possible to determine selectively 1,2-dichlorethane in the presence of chloroform, carbon tetrachloride and 1,1-dichlorethane. The reaction of alkyl- and aryl-chlorsilanes with an aniline solution of ρ-ρ′-biodimethylaminobenzophenone and the determination of mercury by means of the iodine–mercury–copper complex are both selective.

Polarographic methods are highly sensitive and selective. We use a Soviet-made visual-type of apparatus, automatically recording the polarogram, with a dropping mercury cathode and solid rotating electrodes. Of particular interest are the polarographs which are electronically operated, auto-recording, and are of the integrating–differentiating type.

Substances determined polarographically include lead, thallium, zinc, *etc.* Depending on the nature of the impurities present, the determination is carried out against a background of hydrochloric acid or of an acetate buffer. The sensitivity is 0·003 mg/ml.

The sensitivity for the determination of thallium against a background of neutralized sulphuric acid is 0·001 mg/ml.

Zinc, copper, and cadmium are determined against a background of an ammoniacal solution of ammonium chloride. The sensitivity is 0·002 mg/ml.

The conditions have been worked out for the determination of manganese, chromium and zinc in the presence of considerable quantities of iron. The sensitivity is 0·005 mg/ml.

Ozone, chlorine and nitrogen oxides are determined polarographically with a solid rotating anode; the sensitivity is 0·002 mg/ml. By the same method, organic compounds such as nitrobenzene, dinitrobenzene and some others, are determined with a sensitivity of 0·005 mg/ml.

The polarographic method is used for the determination of lead and manganese in biological media.

For the determination of beryllium, lead, zinc, thallium and germanium we also use the spectrographic method.

The luminescence method has a wide application. Its sensitivity for the determination of beryllium with morin (pentahydroxyflavone) can be as good as 0·00001 mg in the volume being analysed. The same method is

used for the determination of phthalic anhydride, oil spray, dibutylphthalate and many other substances.

Catalytic reactions are interesting and offer many possibilities. The determination of hydrogen sulphide and of carbon disulphide, which is based on the catalytic reaction of sodium nitride with iodine, is very sensitive and selective.

We use various forms of chromatographic analysis for the determination of mixtures of toxic substances having similar chemical properties which prove difficult to separate. Thus, we use vapour-phase partition chromatography for the separate determination of amino-compounds and chlorinated hydrocarbons

By non-stationary development chromatography the following mixtures can be separated: divinyl (1,3-butadiene) + ethyl benzene + styrene; xylidine + triethylamine; benzene + toluene + isopentane + hexane + iso-octane.

The daily control of atmospheric pollution in factories is carried out by means of Soviet-made automatic signalling and recording apparatus, which allows a very exact determination of mercury, chlorine, ozone and some other substances in air.

For the determination of air pollution, directly, at the place of work, rapid methods of analysis of the inspection type are used. By means of these it is possible to determine the concentration of a given toxic substance in a very short space of time.

Paper tests have been worked out for the determination of arsine, hydrogen sulphide, aniline, chlorine, and carbon monoxide.

Linear-colorimetric methods using indicator tubes have been established for the determination of hydrogen sulphide, nitrogen oxides, ammonia, sulphur dioxide, petroleum, benzene, chlorine and some other substances.

To conclude, the present state of chemical and physicochemical methods of analysis, as worked out by our own and foreign chemists for atmospheric control, allows one to hope that, for those substances mentioned in the list which still have no methods for their determination, such methods will be developed in the very near future.

The systematic lowering of M.A.C.'s puts the responsibility on chemists of all countries to unite in their efforts for the development of still more sensitive, selective and reliable methods of analysis.