The Mass Spectrometric Determination of Gases Evolved in the Shell Mould Process for Iron Founding

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(Received September 16, 1965)

Resins, such as phenol resin, are used as binders in order to form a shell mould for casting or to manufacture resin-bonded grinding wheels. When molten metal is poured into such a mould or when an article is ground with such a wheel, the binder is thermally decomposed and the decomposed gases contaminate the atmosphere of the work shop, unfavorably influencing the health of the workers.[1] The species of gases evolved are considered to depend to a large extent upon the nature of the binder used, upon the manufacturing process employed, and upon the operating condition of the mould or the grinding wheel.

Information about the evolved gases is necessary before proper measures can be taken to protect the workers from the noxious effects of the gases, but very little is known about them. Tubich et al.[2] have, however, reported that furfural, ammonia, phenol, aldehydes and carbon monoxide are evolved from shell moulds. We have now analysed the gases evolved from shell moulds in a foundry and have detected compounds which have not yet been reported.

The binder used in this mould was a kind of novolak resin. When molten iron was poured into a shell mould, an irritating gas evolved from the mould. The air around the surface was collected in a glass gas-collecting bottle which had been evacuated beforehand. The compounds present in the air of the bottle were then collected by the freeze-out technique reported previously.[3] The frozen-out substance was separated into three parts by isothermal distillation or by sublimation[4] at $-196°C$, $-78°C$ and room temperature. Each fraction was analysed by means of a CEC 21-103C mass spectrometer. The results are shown in Table I. When the gas was evacuated off, some residual substances remained in the sample bottle. After 60 days, appreciable amounts of ammonia and carbon dioxide were still found in the sample bottle. A part of the residue seems to have decomposed into these compounds.

TABLE 1. APPROXIMATE AMOUNT OF ORGANIC COMPOUNDS FOUND IN 760 mmHg OF AIR

Compound	Amount found in μHg
Benzene	8
Toluene	4
Xylene	<2
Phenol	2
Cresol	1
Benzaldehyde	trace

Those compounds which have a low boiling point, such as hydrogen, methane and carbon monoxide, may not be, or cannot be effectively collected by this freeze-out technique. Moreover, we cannot expect as reliable a result concerning those compounds which react with magnesium perchlorate, the drying agent for the isolated concentrate used in the procedure. That is, of the compounds detected, with benzaldehyde only a part of the amount originally present in the air may be collected. Though no acetone or alcohols were detected, it cannot be concluded legitimately that these compounds were not present in the air.

Considering the composition of novolak, it is not unreasonable for the compounds in the table to be detected. Actually, in a study of the mechanism of pyrolysis, between 500°C and 100°C, of novolak in a vacuum, we have identified all the compounds listed in the table as pyrolytic products of the resin,[5] though the mechanism of the production of the compounds in the foundry is considered to be somewhat different from that used under our experimental conditions, since the temperature of a part of the mould is much higher, moreover, the sand of the mould may act as a catalyst for the decomposition of the resin, and at least a part of the reaction proceeds in the presence of oxygen and water.

The authors are indebted to Dr. Hajime Matsufuji for bringing Refs. 1 and 2 to their attention, and to Mr. Ryuzo Shiota for his kind discussions and survey of the manuscript.

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