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ACENAPHTHENE SOLVENTS FOR USE IN BUILDING 313
FROST TEST OPERATION

- References: (1) HW-9393, plus attached document HW-9401, page 33. "Process for Canning Uranium Four-Inch Slugs.
 (2) Lehmann and Flury, Toxikologie and Hygiene der technischen Losungsmittel, Berlin, 1938.
 (3) Lozorer, Arch. Exp. Path. Pharmacol., 1941, 19 (1929).
 (4) Huckolls, Nat. Bd. Fire Underwriters, Misc. Hazard, 2375 (1933).
 (5) McConnell, J. Am. Med. Assoc., 190, 762 (1937).
 (6) Barret, MacLean and Cunningham, J. Ind. Hyg. Toxicol., 20, 360 (1938).

INTRODUCTION

Acenaphthene is a low-melting organic compound, $C_{10}H_6(CH_2)_2$, used as a temperature indicating coating for slugs tested in the Frost Test induction coil. In preparation for this test, slugs are coated by spraying a 12 to 24 per cent by weight solution of acenaphthene in a high vapor pressure solvent on the rotating slug. The solvent evaporates, leaving a thin, adherent coating of acenaphthene. This process is completely described in reference 1.

To be entirely satisfactory for this use, a solvent must satisfy four requirements:

- a. Adequate solubility for acenaphthene.
- b. High vapor pressure -- rapid evaporation.
- c. Non-flammability.
- d. Low toxicity.

Carbon tetrachloride, the solvent used at present, is operationally satisfactory but undesirable because of its toxicity. The purpose of this test is to investigate the suitability of various solvents as substitutes for carbon tetrachloride.

SUMMARY

Four solvents were investigated: chloroform, dichloromethane, trichloroethylene and Safety Solvent FO-128. Of these solvents, chloroform was the only one

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equal or superior to carbon tetrachloride in all respects. Dichloromethane produced satisfactory slug coatings but clogged the spray gun with acenaphthene because of its rapid evaporation. Trichloroethylene and Safety Solvent FO-128 were unsatisfactory because of their slow rate of evaporation. Complete information is summarized in Appendix A.

DETAILS

Criteria for Selection

Necessary conditions for an acceptable acenaphthene solvent are non-flammability and high vapor pressure. These conditions are best satisfied by the chlorinated hydrocarbons. The liquid chlorine derivatives of methane were investigated because of their similarity to carbon tetrachloride. Trichloroethylene was tried because of its availability, and Safety Solvent FO-128 was suggested by the 300 Area Safety Engineer.

Toxicity

Various sources disagree on the comparative toxicity of carbon tetrachloride, chloroform, dichloromethane and trichloroethylene. Reference 2 rates carbon tetrachloride, chloroform, and trichloroethylene by increasing order of vapor toxicity: carbon tetrachloride, trichloroethylene; and chloroform. Reference 3 rates the solvents in order of increasing toxicity (both for light narcosis and lethal toxicity): carbon tetrachloride; dichloromethane; trichloroethylene; and chloroform.

In contradiction to the above opinions, reference 4 states that for a 2-1/2 per cent by volume vapor concentration of each of carbon tetrachloride, chloroform, and dichloromethane, the carbon tetrachloride and chloroform vapors were both lethal to guinea pigs after a one hour exposure while dichloromethane was not lethal after two hours exposure. Reference 5 states that carbon tetrachloride is more toxic than chloroform. Its narcotic effect is less, but the effect on heart, kidneys, and liver is much more rapid. Reference 6 further states that carbon tetrachloride is considerably more toxic than trichloroethylene. No information was available on Safety Solvent FO-128.

Rates of Evaporation

A rough comparison of evaporation rates was made by measuring the time necessary for a thin film of the solvent to evaporate from a smooth metal surface. This showed Safety Solvent FO-128 to be unsatisfactory for Frost Test use as it evaporated approximately ten times more slowly than trichloroethylene, which was the slowest drying of the chlorinated hydrocarbons.

Use Test

Chloroform, dichloromethane, and trichloroethylene were each used for spraying approximately 190 slugs. The operational characteristics of each of these solvents were compared with those of carbon tetrachloride.

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Chloroform gave better results in the spraying operation than carbon tetrachloride. A faster spraying rate was obtained because of the shorter drying time and the resulting acenaphthene coat on the slug was thinner and more adherent.

Dichloromethane produced a slug coating similar to that obtained with chloroform. After spraying approximately 150 slugs, however, the spray gun clogged with acenaphthene, apparently as a result of the rapid evaporation of dichloromethane from the spray gun nozzle. This difficulty could possibly be overcome, however, by changing the spraying equipment.

Trichloroethylene produced unsatisfactory coatings on the slugs because of its slow drying time. By spraying slowly with the spray gun held at a greater distance from the slug than normally, an acenaphthene coating could be built up on the slug, but the coating was thick and poorly adherent. Normal handling of the slugs after spraying dislodged large flakes of acenaphthene, leaving the bare surface of the slug exposed.

CONCLUSIONS

This test shows that carbon tetrachloride, chloroform, and dichloromethane are all satisfactory solvents for acenaphthene. Of the three, chloroform gives the best results. The difference between the solvents is so slight, however, that the final choice of solvent can be based on the factors of cost and hazard to the operators. The most desirable solvent from the standpoint of toxicity cannot be determined within the scope of this report.

W. K. Kratzer
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APPENDIX A

Solvent	Formula	Average Comparative Drying Times Seconds	Number of Slugs Tested	Acanaphthene Concentration Lbs./Gal.	Use Test Quality of Resulting Coating	Operational Difficulties
Carbon Tetrachloride	CCl_4	5	Normal Production	1.5	Good	None
Chloroform	$CHCl_3$	2	190	2.0	Excellent	None
Dichloromethane	CH_2Cl_2	Less than 1	190	2.0	Excellent	Clogged Spray Gun
Trichloroethylene	HC_2Cl_3	7	190	2.0	Poor	None
Safety Solvent FO-128	Unknown	Greater than 70	None	--	--	--

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