MASTER

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Improvement and Verification of
Fast Reactor Safety Analysis Techniques

Progress Report

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Dee H. Barker and Dean V. Wiberg

Department of Chemical Engineering
Brigham Young University
Provo, Utah

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ABSTRACT

The effect of using Acetone, Benzene, or Toluene as a solvent material in a 4M, Acetyl Chloride-Dimethyl Sulfoxide reaction system was investigated. Maximum void fraction and length of time with void greater than 50% were compared. The Acetone system produced the largest maximum void and longest time above 50% void followed by Benzene and Toluene in descending order.

Seventeen waxes were tested and compared to determine a material suitable to simulate reactor containment materials (e.g. steel, concrete). Waxes were compared on the basis of solubility in the reaction materials, melting point and structural integrity.

INTRODUCTION

In previous experiments Dimethyl Sulfoxide (DMSO) and Acetyl Chloride (AC) were reacted in equimolar amounts as the basis for an internally heated liquid pool. Benzene was used as the solvent. During this contract period the effect of using Toluene and Acetone as alternative solvents was studied.

Also, during this contract period, work was begun on identifying materials and developing techniques to model experimentally the heat transfer and material relocation occurring during a Hypothetical Core Disruptive Accident (HCDA).

SOLVENT COMPARISON

In previous experiments Benzene was used as the solvent in the equimolar DMSO-AC reaction system. In this experiment Toluene and Acetone were compared with the Benzene Solvent System.

The comparison was made by using each solvent in a 4M, equimolar DMSO-AC open reaction. The solvents were compared on the basis of maximum void fraction and length of time above 50% void. The results of this experiment are presented in Table 1.

To determine the void fraction and length of time above 50% void the reaction was run in a 250 ml graduated cylinder. 10 ml of the AC solution was placed in the graduated cylinder. A small amount of ground Bakelite was added to provide nucleation sites. The DMSO solution was then introduced into the reaction vessel by means of a syringe and mechanical syringe pump. The DMSO was introduced at a rate of 24 ml/min. This experimental setup is illustrated in Figure 1.

The reaction was filmed using a super 8 movie camera. From the developed film the void fraction was determined as the difference of the boiled up height minus the liquid height divided by the boiled up height. The length of time for which the void was above 50% was determined by counting the number of frames in which the void was above 50% and dividing this number by the number of frames exposed per second.

WAX COMPARISON

It was desired to find waxes which would model the case in which containment materials (e.g. cladding, concrete, etc.) were soluble in the heat generating medium and other waxes which modeled the case in which containment materials were relatively insoluble.

It was also desired that the waxes chosen have both a melting point and a heat of melting low enough to allow substantial melting with the temperature and heat generated by the reaction system. It

was also desired that the properties of the wax be such that the wax could be cast into forms free from such structural imperfections as cracks, fissures or granulation.

Seventeen waxes were compared. These waxes consisted of natural, micro-crystalline, paraffin and polyethylene glycol waxes. Two qualitative methods were employed as a preliminary elimination of those waxes which did not meet the requirements previously mentioned. To evaluate the molding characteristics of the waxes each was cast under several different conditions. The second method of comparison was to compare the solubility of each wax in the components of the reaction system. The results of these comparisons are tabulated in Table 2.

The mold consisted of a 6 inch length of 2 1/2 inch inside diameter polypropylene tubing. The tubing was cut lengthwise into two equal sections. The two sections were placed together and held in place by four worm drive strap clamps. One end of the tube was stoppered with an aluminum foil covered rubber stopper. A test tube of 25 mm outside diameter was placed inside the mold in a concentric fashion, to a depth of approximately 3/4 inch above the rubber stopper. The test tube was stoppered with a two hole rubber stopper with glass tubing inserted through the holes of the stopper. This arrangement is illustrated in Figure 2.

The glass tubing in the test tube was connected to a temperature controlled water source in such a fashion that water could be circulated through the tube. This allowed the rate of heat removal from the wax to be controlled. Molten wax was placed inside the mold and allowed to cool to room temperature. Hot water was then circulated through the test tube. This caused a thin film of wax to melt around the

test tube. The test tube was removed leaving a cavity in which the DMSO-AC reaction could then be conducted. Each casting was then visually inspected for structural flaws such as fissures, granulation, etc.

To compare solubilities a 0.1 g to 0.25 g sample of each wax was placed in an individual 20 ml, capped scintillation vial. 10 mls of a solvent at room temperature was then added. The vial was observed for any immediate results. The vial was observed approximately 24 hours later for any further results.

AREAS FOR FURTHER INVESTIGATION

There are several areas which will be investigated in the future. The solubility of the waxes chosen to simulate containment materials will be determined quantitatively at the conditions which will be encountered during the DMSO-AC reaction. DMSO-AC reactions will be conducted in the castings to determine the geometry of the melt. This will be done in both open and closed systems. Movies of the reaction occurring will be taken to allow study of the time dependent nature of the melt. This will be accomplished by cutting the casting lengthwise along the axis of the cylindrical cavity. A piece of glass plate will then be fused to the face of the cut casting. The reaction will then be observed and filmed through the glass plate.

TABLE 1

4M open DMSO-AC system

Solvent	Acetone	Benzene	Toluene
Max. Voed	80%	60%	0%
Length of time above 50%	8 sec.	4 sec.	0.sec.

TABLE 2

g sample/ comment (see following page)

Wax	Type	Casting	Hardness (see Legend)	M.P °C	Sol- vent vol (MIS)	Acetone	Acetyl Chloride	Benzene	Dimethyl Sulfoxide	Sulfuric Acid	Tolune
Polyethylene Glycol 600 Mono Stearate	Polyethylene Glycol	Good		33-38 _g	7	—	0.11g	0.14g	0.15g	—	—
Petronauba W		Good			10	—	0.25g	0.25g	.25g	0.25g	—
Petrolite C-8500	Micro Crystalline	Fair			10	—	0.25g	0.25g	0.25g	0.25g	—
Be Square 190/195 Amberwax	Micro Crystalline	Good		88 _g	10	—	0.25g	0.25g	0.25g	0.25g	—
Carnavba	Natural	Poor		83-86 _g	10	—	0.25g	0.25g	0.25g	0.25g	—
ES-254	Micro Crystalline	Poor	1.3 _g	35 _g	10	0.1g	0.1g	—	0.1g	—	0.1g
TS-254Δ	Micro Crystalline	Poor	0.3g	93 _g	10	0.1g	0.1g	—	0.1g	—	0.1g
TS-970	Micro Crystalline	Poor	0.1 _g	78 _g	10	0.1g	0.1g	—	0.1g	—	0.1g
TS-254	Micro Crystalline	Poor	0.35 _g	63 _g	10	0.1g	0.1g	—	0.1g	—	0.1g
Sun 3420		Good	50 ₇	55 ₇	10	0.2g	0.2g	0.2g	0.2g	—	0.2g
Sun P116		Fair	90 ₇	46 ₇	10	0.2g	0.2g	0.2g	0.2g	—	0.2g
Sun P127		Good	60 ₇	55 ₇	10	0.2g	0.2g	0.2g	0.2g	—	0.2g
Sun 4412		Good	20 ₇	60 ₇	10	0.2g	0.2g	0.2g	0.2g	—	0.2g
Sun P137		Fair	20 ₇	60 ₇	10	0.2g	0.2g	0.2g	0.2g	—	0.2g

TABLE 2 (cont.)

Sun P-155		Good	20 ₇	67 ₇	10	0.2g 1	0.2g 1	0.2g 6	0.2g 1	—	0.2g 3
Sun P-5512		Good	20 ₇	66 ₇	10	0.2g 1	0.2g 3	0.2g 6	0.2g 1	—	0.2g 6
Sun 7717		Poor	50 ₇	76 ₇	10	0.2g 1	0.2g 3	0.2g 3	0.2g 1	—	0.2g 2.3

COMMENTS AND FOOTNOTES - (from table 2)

1. Small amount of sample went into solution.
2. Color change occurred
3. Approximately 1/2 of sample went into solution.
4. Loss of structural integrity (e.g. dispersed, flockulant, etc.)
5. Cloudy solvent.
6. Wax was completely dissolved in solvent.
7. Penetration at 100° F (ASTM D-1321) Correspondence from Sun Petroleum Products Co. (Dec. 1, 1978)
8. Penetration with 100 g load, mm (ASTM D5-65) Technical Data Sheet, NP Series, TDS No. 3, IMC Chemical Group, Inc., Hillside, Ill.
9. Bennett, Industrial Waxes, Vol. 1, Chemical Publishing Co., Inc. New York, (1963)

Figure 1. Experimental Setup - Open System

Figure 2