UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

APR 4 1979

MEMORANDUM FOR: Robert B. Minogue, Director
Office of Standards Development

FROM: Saul Levine, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER # 49 IN VITRO DISSOLUTION OF URANIUM PRODUCT SAMPLES FROM FOUR URANIUM MILLS

This memorandum transmits the results[1] of completed research on the measurement of the solubility of various forms of yellowcake in vitro. This work was performed by the Inhalation Toxicology Research Institute of the Lovelace Biomedical and Environmental Research Institute under the direction of the Environmental Effects Research Branch of RES.

Your memorandum dated February 14, 1978, a supplement to RR-SD-77-30, requested measurements of the dissolution half-life of yellowcake in simulated lung fluid.

The yellowcake samples were obtained from the production lines of each of four uranium mills. A 25-29 mg portion of each sample was secured between two nucleopore filters and placed in 200 ml of solvent. The solvent was changed every two hours for the first six hours and periodically during the next thirty days. The uranium content of each solvent sample and of the material remaining in the filter sandwich was determined by fluorimetry. Two solvent systems were studied: a simulant of an ultrafiltrate of blood serum and 0.1M HCl. The chemical form of the uranium in each sample was determined by X-ray powder diffraction. Infrared spectroscopy was also employed on some samples of yellowcake which were of low crystallinity.

The results of the dissolution studies in the serum simulant are presented graphically in Figure 1. The data, plotted as the percent of uranium undissolved versus time, were fitted using a non-linear least squares computer program with a two-component or three component negative exponential equation of the form

$$\% \text{ undissolved} = A_1 e^{-\lambda_1 t} + A_2 e^{-\lambda_2 t} + \ldots A_n e^{-\lambda_n t}$$

where t, in hours, is the elapsed time. The percent of total material remaining and the corresponding dissolution half-times associated with

[1] In Vitro Dissolution of Uranium Product Samples from Four Uranium Mills, NUREG/CR-0414.

each component are given in Table 1. Corresponding plots and data for the 0.1M HCl are given in Figure 2 and Table 2.

TABLE 1

Calculated Values for Percent of Total Material Remaining and Half-Times of Dissolution for Four Uranium Product (Yellowcake) Samples as Determined in in vitro Dissolution Studies Using Serum Simulant + DTPA as Solvent

Uranium Mill	%	$T_{1/2}$ (hours)	%	$T_{1/2}$ (hours)	%	$T_{1/2}$ (hours)
Anaconda	24.9	2.4	53.1	16.1	22.0	16,900
Kerr-McGee	63.6	14.2	16.4	85.1	20.0	13,000
Homestake	60.9	16.0			39.1	7,800
Exxon	25.5	3.4			74.5	6,600

TABLE 2

Calculated Values for Percent of Total Material Remaining and Half-Times of Dissolution for Four Uranium Product (Yellowcake) Samples as Determined in in vitro Dissolution Studies Using 0.1M HCl as Solvent

Uranium Mill	%	$T_{1/2}$ (hours)	%	$T_{1/2}$ (hours)	%	$T_{1/2}$ (hours)
Anaconda	99.4	0.5	0.3	8.6	0.3	183
Kerr-McGee	99.5	0.5	0.06	23.0	0.4	186
Homestake	81.1	0.6	8.6	40.0	10.3	600
Exxon	51.0	2.1	38.3	85.5	10.7	208

Results of the X-ray powder diffraction studies showed that the samples were composed of alpha-U_3O_8 and $(NH_4)_2U_2O_7$ (ammonium diuranate). One sample consisted primarily of alpha-U_3O_8; one was a mixture of alpha-U_3O_8 and $(NH_4)_2U_2O_7$; and the other two consisted primarily of $(NH_4)_2U_2O_7$.

The physical significance of the two-component dissolution rate curves is that the first, more rapid component was due primarily to the dissolution of the $(NH_4)_2U_2O_7$ fraction, while the slower component was due

primarily to the remaining U_3O_8 fraction. For the three-component curves the first component represents the dissolution of $(NH_4)_2U_2O_7$ and the third component the U_3O_8. Since the X-ray diffraction data indicate only two chemical forms of uranium are present, the second component may be due to the very wide range of particle sizes present.

As stated in your memorandum dated February 14, 1978, the results of this research will be used to determine whether yellowcake should be considered a soluble compound with respect to compliance with 10CFR20. The data obtained using the serum simulant show that 25 to 64 percent of all yellowcake samples tested dissolved with half-times less than 16 hours. Ideally solubility classifications should be based on the dissolution half-times of the particular product under consideration. If this is not practicable, we believe the data presented here indicate that yellowcake should be treated as a Class D compound for purposes of exposure control. This is in agreement with the results obtained by the Battelle Pacific Northwest Laboratory[2/] under their technical assistance contract with the Office of Standards Development.

If you have any questions with regard to this report, please contact Dr. Judith D. Foulke (427-4358).

Saul Levine

Saul Levine, Director
Office of Nuclear Regulatory Research

Enclosure: In Vitro Dissolution
of Uranium Product Samples frm
Four Uranium Mills, NUREG/CR-0414

2/ Solubility Classification of Airborne Products from Uranium Ores and Tailings Piles, in press.

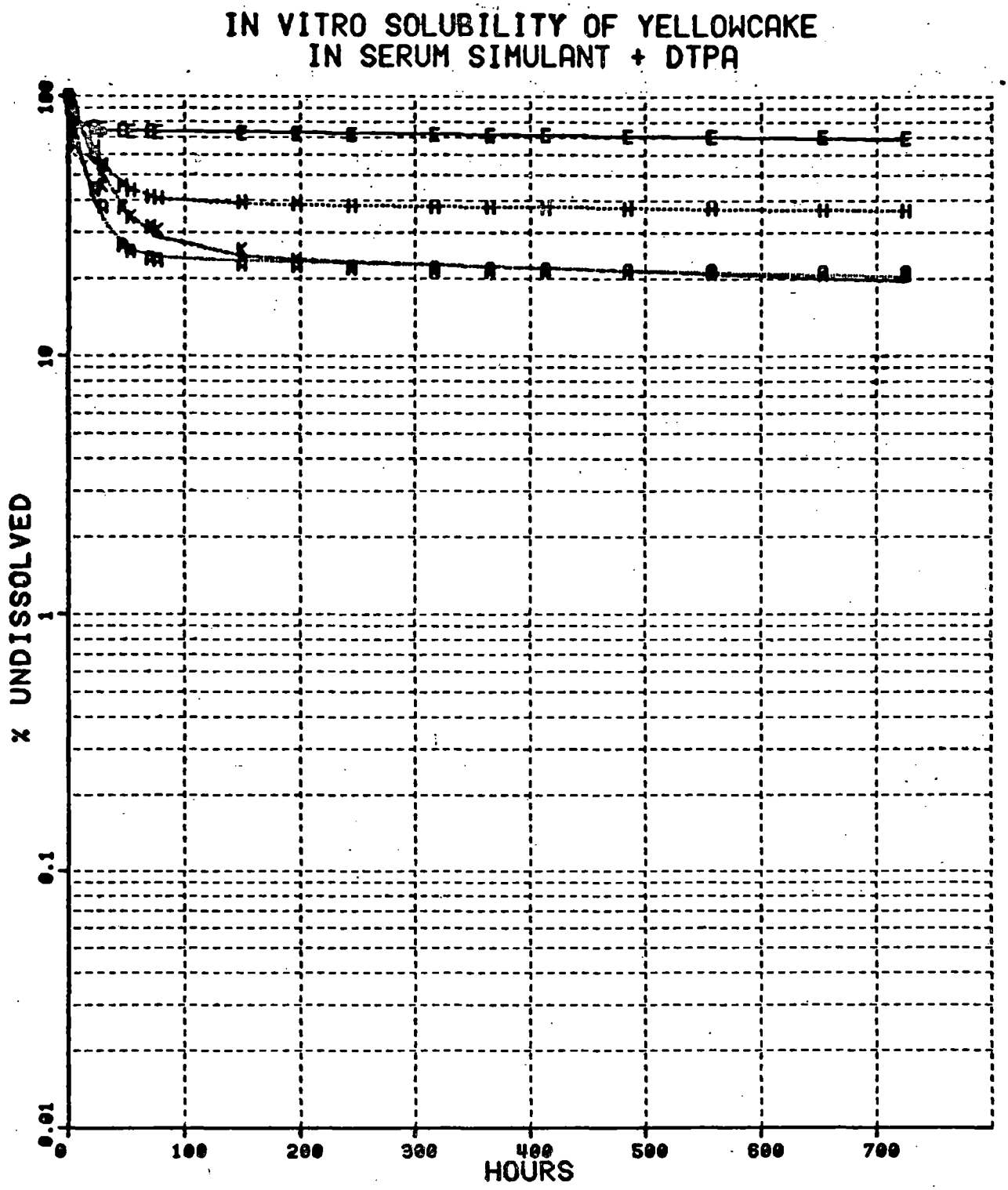

Figure 1. *In vitro* dissolution of yellowcake obtained from four uranium mills in serum simulant containing DTPA. E, Exxon Mill; H, Homestake Mill; K, Kerr-McGee Mill; A, Anaconda Mill.

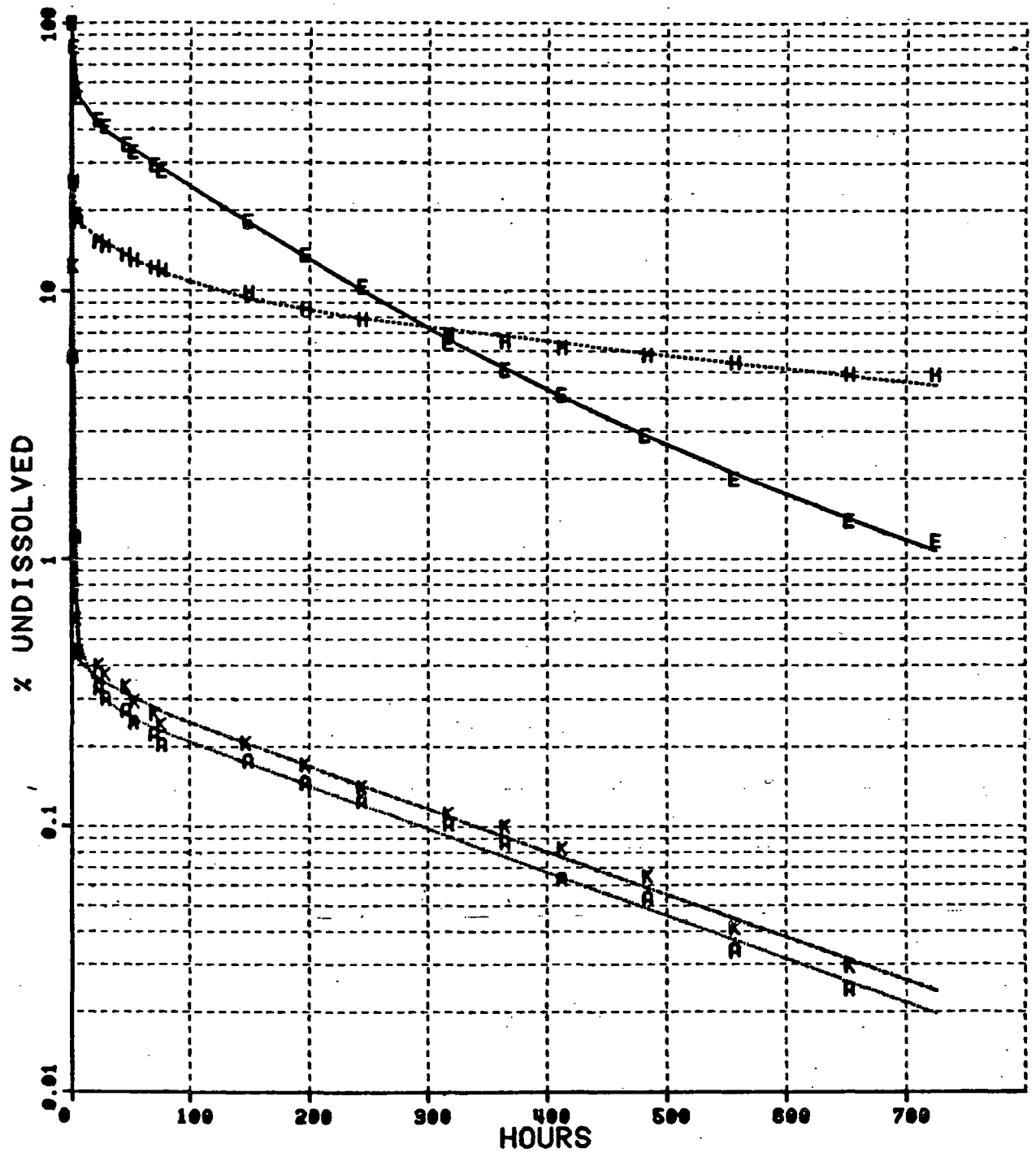

Figure 2. *In vitro* dissolution of yellowcake obtained from four uranium mills in 0.1 M HCl. E, Exxon Mill; H, Homestake Mill; K, KerrMcGee Mill; A, Anaconda Mill.