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PASSIVATION OF AMMONIUM NITRATE SURFACE
FOR USE IN MINOL-2

Andrew F. Smetana, et al

Picatinny Arsenal
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September 1972

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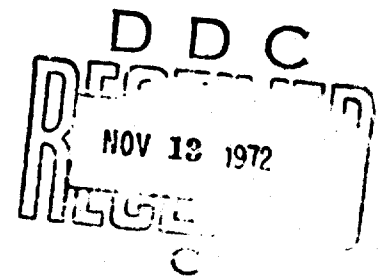
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TECHNICAL REPORT 4374

PASSIVATION OF AMMONIUM NITRATE SURFACE
FOR USE IN MINOL-2

ANDREW F. SMETANA
THOMAS C. CASTORINA



SEPTEMBER 1972

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Prilled, spheroidized, and granular ammonium nitrate (AN) was coated with polychloro-p-xylylene (parylene C) by a vapor deposition polymerization technique. Particles of AN with a 0.2% coating remain free flowing after long exposure to ambient conditions. The effectiveness of the coating as a moisture barrier on the three forms of AN was found to be in the order, spheroids > prills > granules. Water adsorption isotherms and hygroscopicity determinations indicate that a 0.7% coating hydrophobes the surface of AN by approximately one order of magnitude. The parylene C/AN interface exhibits chemical and physical stability at elevated temperatures. The coating appears to be thermally stable in the Minol-2 matrix, and tends to inhibit reactivity between AN and TNT. The thermal sensitivity of Minol-2 to initiation, which is governed by the most sensitive constituent, AN, is unaffected by a 0.7% coating.		

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FOR USE IN MINOL-2

by

Andrew F. Smetana
Thomas C. Castorina

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Explosives Division
Feltman Research Laboratory
Picatinny Arsenal
Dover, New Jersey

III

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ABSTRACT

Prilled, spheroidized, and granular ammonium nitrate (AN) was coated with polychloro-p-xylylene (parylene C) by a vapor deposition polymerization technique. Particles of AN with a 0.2% coating remain free flowing after long exposure to ambient conditions. The effectiveness of the coating as a moisture barrier on the three forms of AN was found to be in the order, spheroids > prills > granules. Water adsorption isotherms and hygroscopicity determinations indicate that a 0.7% coating hydrophobes the surface of AN by approximately one order of magnitude. The parylene C/AN interface exhibits chemical and physical stability at elevated temperatures. The coating appears to be thermally stable in the Minol-2 matrix, and tends to inhibit reactivity between AN and TNT. The thermal sensitivity of Minol-2 to initiation, which is governed by the most sensitive constituent, AN, is unaffected by a 0.7% coating.

INTRODUCTION

The surface of explosives, either as an interacting boundary layer with various chemical agents, and/or as a localized region in which explosive decomposition can be initiated or catalyzed, can influence the physical and chemical properties of explosives (Ref 1,2). Hence, modifications of the surface offer a variety of possibilities for improving the formulations of explosive systems.

The inherently unstable character of ammonium nitrate (AN) in Minol-2 may be altered favorably by a hydrophobic surface barrier deposited irreversibly. Water could be considered the vehicle, not only for caking via a crystal bridging process, but also for phase changes during temperature cycling (Ref 3). Conceivably, the gamma to beta polymorphic transition at 32°C is accelerated by the presence of water. Water also could cause incipient degradation of AN to nitric acid and ammonium hydroxide as highly reactive products of hydrolysis undergoing secondary reactions with the constituents of the composition.

There are numerous conventional methods reported in the literature (Ref 4 through 8) of modifying the surfaces of explosives using materials in concentrations of 2-5% which act as diluents of the bulk performance potentiality of the explosives. A thorough study of the stability of these coatings has not been reported. One can safely assume that none of these applications act as a vapor barrier to any extent. Any stability of coating, if attained, is by virtue of excessive thicknesses of depositions, and not by an intrinsic adhesive property between adduct and substrate. This is particularly true of waxes and polymers composed of macromolecules spanning microvoids, cracks, and crevices.

The scope of the problem is to achieve, with a minimum of thickness, preferably in the range of 0.1 to 1% by weight of the bulk material, a continuous and stable deposition of barrier material on the surface of explosives. This could be accomplished by the condensation of monomer molecules on the irregular surface subsequently induced to undergo polymerization. By virtue of an intimate replication of the surface on a molecular scale, the polymeric barrier material deposited in this fashion (in contradistinction to the conventional methods) would be locked in position on the surface, and hence stabilized.

Deposition of polymer coatings by the polymerization of monomers from the vapor phase (vapor deposition polymerization) (VDP) has been under investigation only in the past decade, and is still in the developmental stage. However, notable success has been achieved in the coatings of powders by this VDP technique (Ref 9-12). In general, polymers, have elastic properties and are thermally and chemically stable, and when deposited in this fashion, form stable protective barriers to reactive gases and vapors.

This report¹ describes the application of the VDP technique to prilled, spheroidized, and granular AN to produce surface modifications that would impart desired flow and noncracking properties, plus phase and chemical stability required for the prevention of growth processes in Minol-2.

EXPERIMENTAL

Ammonium Nitrate - Uncoated (An-u)

Baker analyzed reagent grade, ground with mortar and pestle, was used for the water adsorption isotherm measurements. The surface area of this material was found, by the low temperature argon adsorption method to be $0.76 \text{ M}^2/\text{g}$.

Prilled, spheroidized, and granular forms were obtained from Mississippi Chemical Company, Yazoo, Miss., Chevron Chemical Company, Richmond, California, and Commercial Solvents Corporation, Sterlington, La., respectively.

Aluminum Powder, Atomized

Lot No. Alcoa-;003, Type 3, Grade F, Class 7.

TNT

Type I, Flake form obtained from DuPont, Lot No. DUP-4-62.

¹This document constitutes a final report on the passivation of the surface of AN as part of the overall Explosive Fills program to investigate the chemical and thermal stability of Minol-2.

Plant Minol-2

Plant Minol-2 was received from Tooele Army Depot, Tooele, Utah.

Experimental Minol-2

Individual one to two gram samples were made separately in ratios of 2:2:1 of TNT:AN:AL, respectively. The AN was polymer coated and uncoated, as indicated.

Water

The water used in the adsorption isotherm measurements and dosing experiments (see below in this section) was distilled water, redistilled from alkaline permanganate and sulfuric acid, followed by a third distillation. The water was degassed prior to use by freeze-thawing under vacuum at -78°C .

Vapor Deposition Polymerization (VDP)

The procedure for the VDP technique (detailed elsewhere, Ref 9) is described briefly as follows: A measured quantity of dichloro-substituted p-xylylene (pyrylene C) was placed in a porcelain boat, and the boat placed in the distillation zone of the coater apparatus. A one-pound batch of AN-u was placed in a plastic container at the opposite end of the coater. The system was then evacuated to 10^{-3} Torr using a forepump protected with a -78°C trap. The distillation zone was heated to approximately 150°C and the pyrylene C distilled into the pyrolysis zone heated to 600°C . The pyrolysis gas consisting of the biradical form of the monomer was then led into the deposition chamber containing the AN-u. The deposition chamber was held at ambient temperature, and the coating of AN proceeded with a tumbling action by rotation of the plastic container.

All samples of AN-u were coated with pyrylene C in increments of 0.2% by Union Carbide Corporation, Bound Brook, New Jersey, at a service cost.

Hygroscopicity Tests

Hygroscopicity determinations were run at 33, 52, 76, and 100% relative humidity (RH) at 23°C with saturated solutions of magnesium chloride, sodium dichromate, sodium chloride, and distilled water, respectively. Three gram samples of parylene C-coated AN (AN-c) and AN-u (as controls) exposed to these RH's in desiccators kept at $23 \pm 1^\circ\text{C}$, were weighed periodically and the rate of water uptake reported in percent gain in weight with time (hours).

Water Adsorption Isotherms

The adsorption isotherms were conducted gravimetrically at 25°C, using a Cahn RG Electrobalance, located (on loan) at Lehigh University, which has an absolute sensitivity of 1 microgram with a maximum sample load of 1 gram. Pressures were measured to three significant figures with an Alphatron vacuum gauge from 10^{-3} to 10^3 Torr.

Thermal Stability Test

One gram samples were placed in break-seal ampoules provided with flame seals. The charged ampoules were affixed to a vacuum manifold and outgassed at ambient temperature for 5-7 days to 10^{-6} Torr before flame-sealing. The sealed ampoules were placed in a constant temperature bath set at $120^\circ \pm 1^\circ\text{C}$ and heated for 40 and 80 hours as designated. The gases generated by the heating were fractionated at -78°C and ambient temperature and analyzed mass-spectrometrically.

In the experiments where water was added to the samples, the following procedure was used: After the outgassing step (cited above), 6 Torr of water vapor was dosed into the sample systems. Prior to flame-sealing, the valve, to which an ampoule was attached, was closed, and a liquid nitrogen bath applied to freeze the water away from the flame-seal region. The section of the ampoule containing the sample/water which had been frozen was brought to ambient temperature after the flame-sealed tip had cooled. The sealed ampoules then were heat-treated and analyzed as described above for the anhydrous samples.

Explosion Temperature Test

The explosion temperature determinations were run on the modified PA Explosion Temperature Apparatus described elsewhere (Ref 13).

RESULTS AND DISCUSSION

Hygroscopicity Determinations

The passivation of the surface of AN was studied with the three different forms being evaluated for use in Minol-2 (Ref 14). They are prilled AN (pAN), spherodized AN (sAN) and granular AN (gAN). These forms are also well suited for studying the effectiveness of the VDP technique described in the experimental section. Examination at 50 power magnification showed the prills to possess annular cavities and the smoothest surface; the spheroids to be devoid of any cavitations but with a smooth knobby topography; and the granules to have characteristic sharp edges and corners. The extent of passivation by the VDP of parylene C in various thicknesses ranging from approximately 0.2 to 2% by weight of AN was demonstrated first by hygroscopicity determinations. These are summarized in Fig 1 through 8.

Figures 1 and 2 show equilibrium values (plateau portion of curve) in the rate of water uptake attained in 24 hours for uncoated, prilled AN (pANu) and parylene C-coated prilled AN (pANc) at 33% RH; in 48 to 72 hours for pANc and pANu, respectively, at 52% RH. Such equilibrium values are indicative of water being adsorbed on the surface of AN in molecular layer quantities. The decreasing slopes of the adsorption curves with increasing polymer coverages demonstrate the hydrophobing action of parylene C coatings. The low concentrations of water on the surface of ANu at these relatively low humidities do not dissolve enough AN to effect crystal bridging, and hence ANu particles were not observed to cake under such exposures. Since RH's above 33-52% are more likely to be encountered in the normal handling of AN, extensive hygroscopicity determinations were made on all three forms of AN at 76 and 100% RH (Fig 3 through 8).

In these sets of curves there is a noticeable absence of equilibrium values in the rate of water uptake. Instead, the water uptake appears to rise almost monotonically with time. These curves may be classified as the Henry type, indicative of dissolution of water vapor into the bulk of the AN substrate, or absorption. This is true of the ANc as well as of the ANu samples. However, with the exception of gAN, the samples coated with a minimum of 0.7% polymer produce curves at 76 and 100% RHs that fall in with the family of curves that are markedly slower in the rate of absorption than those of the ANu controls. The comparative magnitude and analysis of these differences can be illustrated more clearly by Figures 9 and 10. The curves for pANc and sANc are superposable at 76 and 100% RHs and are characterized by a sharp bend at the point corresponding to 0.7% coating. A slight difference in these two samples may be observed above the 1.5% coatings at 100% RH (Fig 10). The sAN appears to be coated more effectively with increasing thicknesses of parylene C deposition. The difference in percent water absorption between the coated (ca. 2%) and uncoated samples of AN is approximately one order of magnitude for pAN and sAN, and only a factor of two for gAN. Apparently, because of the sharp edges, corners, and flat surfaces, granules do not coat completely by the tumbling action employed. A sample of sAN coated with 2% diatomaceous earth absorbed as much moisture as the control, sANu. The rate of water absorption is reduced significantly for the pANc and sANc with parylene C. In addition, coatings of as little as 0.2% imparted free-flowing behavior to particles of AN even after increases up to 5% of water uptake.

Water Adsorption Isotherms

A more detailed evaluation of the water interaction with ANu and ANc was performed by adsorption isotherm determinations. The AN used for the adsorption isotherms presented in Figures 11 and 12 is ground, reagent grade with a surface area of $0.76 \text{ M}^2/\text{g}$. At the high coverages plotted in Figure 11, the AN surface undergoes mass water adsorption at relative pressures above 0.53. This is consistent with the hygroscopicity data which could be obtained only at RHs above 52%. At the low coverages plotted in Figure 12, water interaction with the surface of AN is shown, by the sharp rise and knee of the curve, to be strong. True surface absorption takes place at relative pressures below 0.5 and is reversible

confined to the surface region. The water area calculated from the curve is $0.40 \text{ M}^2/\text{g}$ and the corresponding hydrophilicity of the surface of AN is 53%.

Water adsorption isotherms are presented in Figures 13 and 14 as a function of thickness of parylene C coating on sAN at high and low water coverages, respectively. The adsorption isotherms in Figure 13 support the data in Figures 9 and 10, and illustrate the extent to which the surface of AN is hydrophobed by the polymer coating. The high pressure points show a definite but limited, penetration of water through the coating. At the low coverages (Fig 14) the water interaction is shown to be progressively diminished as the thickness of coating increases. For the 3% coated sample, the water interaction is essentially with the hydrophobic parylene C substrate.

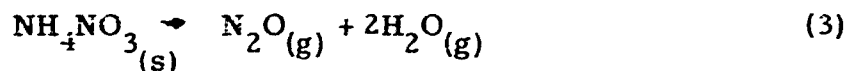
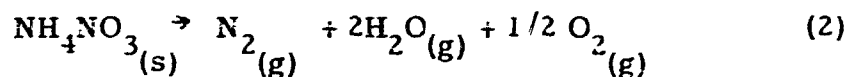
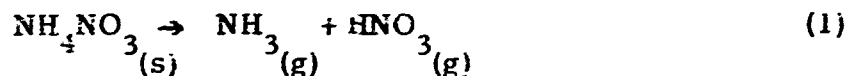
Thermal Stability Determinations

A minimum of five days of degassing at 50°C and 10^{-6} Torr was required to reduce the trace levels moisture and air entrapped in the interstices of the high density crystalline mass of pAN, sAN, and gAN. All samples, including the plant Minol-2, were therefore treated in this manner prior to performing the thermal stability determinations.

Water and hydrocarbon fractions detected in all sample systems after the heat treatment at 120°C could not be determined quantitatively; and since their concentrations also represented minor contributions to the total gas volumes evolved, the reported analyses in Tables 1 through 5 are on a water - and hydrocarbon - free basis. The thermal stability test used in this study served to establish the relative order of stability among the sample systems tested. Therefore, no attempt was made to equate the total gas volumes to pressures and compare the data to the standard vacuum stability acceptance values (Ref 15).

Although NO_2 was apparently present as a product of decomposition of TNT, its analysis was not included because of the difficulty associated with the mass spectrometric determination. The quantities of O_2 and NO , also derived primarily from TNT, are perhaps unusually low because of their interaction to form NO_2 .

AN is reported (Ref 16) to decompose thermally, according to the three modes described in equations 1 through 3.



where the ΔH 's are 44.2, -28.3 and -8.84 kcal/mole, respectively.

The absence of N_2O , NH_3 , and HNO_3 in the gases, detected mass spectrometrically, would indicate that AN decomposes primarily under the conditions of the test, according to the reaction in Equation (2).

The N_2 may be considered as being derived from TNT as well as AN, CO_2 essentially from TNT, possibly with some contribution from parylene C, and H_2 principally from $\text{Al}/\text{H}_2\text{O}$ interaction and TNT decomposition. (No chlorine, as derived from parylene C, was detected in any of the samples analyzed.) Hence, N_2 , CO_2 , and H_2 become the significant gases indicative of trends in the comparative analysis of the data.

The differences in the total amount of gases (hereafter understood to be in reference to the significant gases) shown in Table 1 are negligible among the experimental Minols containing the three different forms of ANu and ANc (0.2 and 0.7%). However, the total amount of gases evolved from the plant Minol is five times greater than that from the experimental Minols. This relative instability may be associated with the age of the Minol-2. The plant Minol is presumably at least a year older than the freshly prepared experimental Minols. The aging effect could possibly involve incipient formation of degradation products which are thermally unstable at 120°C. Only the 0.7% parylene C-coated

AN samples were included in all of the other thermal stability determinations (Tables 2 through 5), because no differences were exhibited in comparison to the 0.2% coatings cited in Table 1; and the 0.7% coating represented the effective minimum barrier thickness (on pAN and sAN) that would be recommended for use in Minol-2.

The effect of water on the thermal stability of Minol-2 containing the three forms of AN coated with parylene C is shown in Table 2. When the cross-comparison is made with Table 1 (without the addition of water), the water addition appears to demonstrate the protective effect of the coating of pAN and sAN, but not on gAN. This observation is consistent with the data presented in Figures 9 and 10, which illustrates the ineffectiveness of the coating on gAN as a moisture barrier.

The experiments described in Table 3 were conducted to demonstrate the effect of water on the thermal stability of parylene C as an oxidizable material in contact with AN. Water was included to approximate ambient conditions likely to be encountered in the storage, shipment, and normal handling of AN. The data shows the apparent stability of the coated AN to be independent of the water addition. This would indicate that there is no hazard involved with coatings of parylene C on AN.

To enhance the trend of incipient reactions amongst the various combinations of Minol-2 constituents, thermal stability determinations were run for 80 hours at 120°C. The results are listed in Table 4. The thermal stability of neat TNT is shown to be independent of the presence of water. The lack of reaction between water and Al, as indicated by the small volume of H₂ released, is probably due to the pH of the distilled water being close to neutral. Consistent with these observations, the stability of TNT in contact with Al is shown to be unaffected by the presence of water. However, the observed indication of incipient reactivity between Al and TNT in the absence of water would seem to be anomalous. Possibly, under anhydrous conditions, Al functions as a heat sink for the more efficient transfer of thermal energy to TNT, causing the observed incipient decomposition. Of particular interest is the observed tendency of the ANu reactivity with TNT to be enhanced by the presence of

water, and the effectiveness of the coating on AN as a barrier to this interaction with TNT. Based on the data presented in Tables 1 through 4, the major source of the total volume of gas evolution can be attributed to the inherent chemical instability of the ANu/TNT interface. This interaction takes place although ANu was not observed to be wetted by TNT at the end of the test, as was the ANc.

Sensitivity to Thermal Initiation

Table 5 shows plant Minol with a shorter time to explosion than the experimental Minols, which may be due to the aging effect cited above in the section under Thermal Stability. The thermal sensitivity is lowered by the presence of Al, perhaps for the same reason postulated previously, i. e., that Al acts as a heat sink and efficiently transfers the thermal energy from the hot bath to the TNT. However, the thermal sensitivity of TNT/Al is significantly lower than either of the Minol compositions or neat AN.

Comparison of the times to explosion of the neat AN to those of the experimental Minols shows the thermal sensitivity of the experimental Minols to be independent of the coatings on AN, the different forms of AN, and strongly influenced by the intrinsic properties of AN.

CONCLUSIONS

The VDP method of coating powders holds promising possibilities for the modification of the surface properties of explosives. The data presented in this report demonstrate the feasibility of the method for passivating AN in Minol-2 with a polymer (parylene C) coating that is chemically and physically stable at elevated temperatures. The effectiveness of the coating as a moisture barrier on the three forms of AN studied was found to be in the order, spheroids > prills > granules. Particles of AN with a 0.2% coating remain free-flowing even after long exposures to ambient conditions of temperature and moisture, a 0.7% coating is the maximum necessary to reduce absorption of water by one order of magnitude, and inhibit reaction at the AN/TNT interface in Minol-2.

However, before coated AN can be recommended for use in Minol-2, stability and homogeneity of dispersion in the Minol-2 matrix, as well as detonation velocities of the experimental compositions should be determined.

Although the parylene C precursor is easily activated by thermolysis, and the VDP method is adaptable to plant procedures, the cost of coating AN is practically prohibited by the present price (\$250/lb) of the starting dimer material. If further investigation would warrant its use on a large scale, the cost could perhaps be adjusted to acceptable levels. At any case, if the coating on explosives, in general, can solve some of the problems associated with multicomponent systems, as has been indicated thus far in this study, then investigation should be pursued of other systems of activated monomer species requiring starting materials which are available at lower cost.

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TABLE I

cm³ Gas (STP)/g Sample
Experimental Minol-2

^a 120°C for 40 hours

TABLE 2
Effect of Water Addition^a on Stability^b of Minol-2
Containing Parylene C-Coated AN

Gas	Plant Minol-2	cm ³ Gas (STP)/g Sample					
		Experimental Minol-2			With uncoated AN		
		Prills	Spheroids	Granules	Prills	Spheroids	Granules
Nitrogen	.365	.010	.010	.075	.058	.058	.074
Oxygen	.002	.001	.001	.001	.001	.001	.001
Carbon Dioxide	.038	.010	.010	.018	.005	.006	.018
Hydrogen	.007	Trace	Trace	.002	.002	.001	.001
Nitric Oxide	.001	Trace	.001	<.001	.001	.001	.003
Total	.413	.021	.022	.096	.066	.067	.097

^a 6 Torr water vapor

^b at 120°C for 40 hours

TABLE 3
Effect of Water Addition^a on Stability of Parylene C-Coated AN

Gas	cm ³ Gas (STP)/g Sample											
	Uncoated AN						0.7% Coated AN					
	Prills		Spheroids		Granules		Prills		Spheroids		Granules	
	w/o	w	w/o	w	w/o	w	w/o	w	w/o	w	w/o	w
	H ₂ O	H ₂ O	H ₂ O	H ₂ O	H ₂ O	H ₂ O	H ₂ O	H ₂ O	H ₂ O	H ₂ O	H ₂ O	H ₂ O
	Addn	Addn	Addn	Addn	Addn	Addn	Addn	Addn	Addn	Addn	Addn	Addn
Nitrogen	.005	.006	.018	.019	.028	.038	.006	.006	.015	.018	.016	.026
Oxygen	.001	.001	.004	.005	Trace	<.001	.001	.001	.002	.002	Trace	<.001
Carbon Dioxide	<.001	<.001	.001	.001	.023	.020	.001	<.001	.001	.001	.016	.022
Hydrogen	<.001	Trace	Trace	Trace	Trace	.001	Trace	Trace	<.001	Trace	Trace	Trace
Nitric Oxide	Trace	-	.001	Trace	<.001	.001	Trace	Trace	<.001	<.001	Trace	.002
Total	.006	.007	.024	.025	.051	.060	.008	.007	.018	.021	.032	.051

^a 6 Torr water vapor

^b at 120°C for 40 hours

TABLE 4
Effect of Water Addition^a on Stability^b of Individual
and Combinations of Minol-2 Constituents^c

Gas	cm ³ Gas (STP)/g Sample											
	Without Water Addition						With Water Addition					
	TNT	ANu	ANC	AL	ANu	ANC	TNT	ANu	ANC	AL	TNT	ANu
N ₂	.003	.111	.078	.061	.037	.037	.003	.090	.030	.002	.004	.038
O ₂	Tr	.011	Tr	<.001	.003	.002	Tr	<.001	.001	Tr	<.001	.001
CO ₂	.002	.018	.017	.009	.004	.003	.002	.026	.009	.003	.003	.020
H ₂	Tr	.001	.001	.001	<.001	<.001	Tr	<.001	Tr	.001	<.001	.001
NO	.001	.002	.002	.002	.001	.002	.001	.001	.001	-	<.001	.001
Total	.006	.143	.098	.073	.045	.044	.006	.117	.041	.006	.008	.061

^a 6 Torr water vapor

^b at 120°C for 80 hours

^c Including sANc with 0.7% parylene C

TABLE 5

Thermal Sensitivity^a of Parylene C-Coated AN,
Neat and in Minol-2 Composition

<u>Sample System</u>	<u>Time to Explosion^b (seconds)</u>
Experimental Minol-2 with:	
pANu	1.7
sANu	2.0
gANu	1.9
pAN .2% c	2.2
sAN .2% c	2.7
gAN .2% c	2.0
pAN .7% c	2.1
sAN .7% c	2.2
gAN .7% c	2.0
Neat AN:	
pANu	1.9
sANu	2.0
gANu	2.3
pAN 1% c	2.1
sAN 1% c	2.4
gAN 1% c	2.6
Plant Minol-2	1.6
TNT	6.1
TNT/Al	4.4

^a Determined isothermally at 425°C

^b Standard average deviation ± 0.2

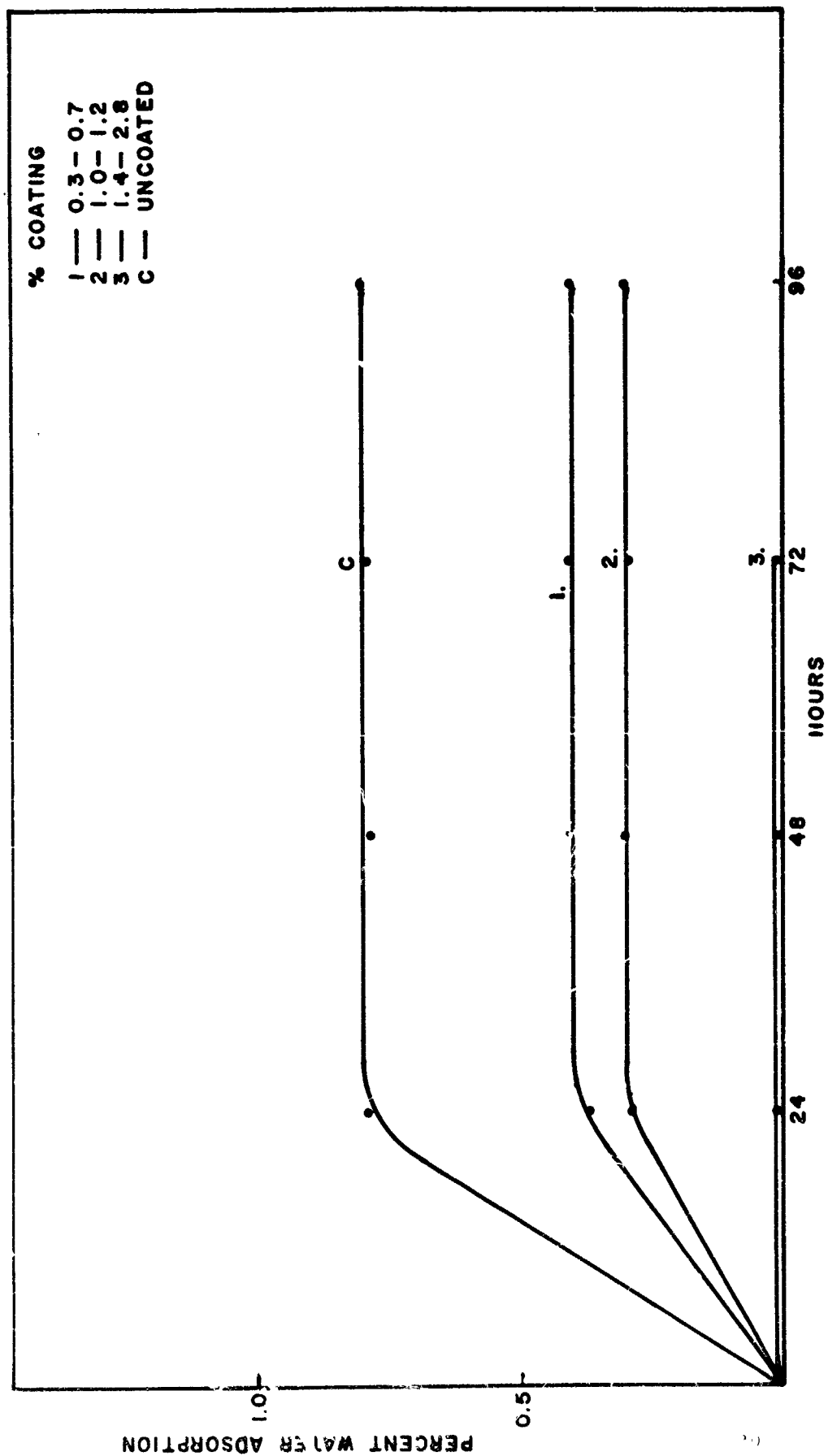


Fig 1 Rate of Water Adsorption of Parylene C-Coated AN (Prilled) at 33% R.H. (23°C)

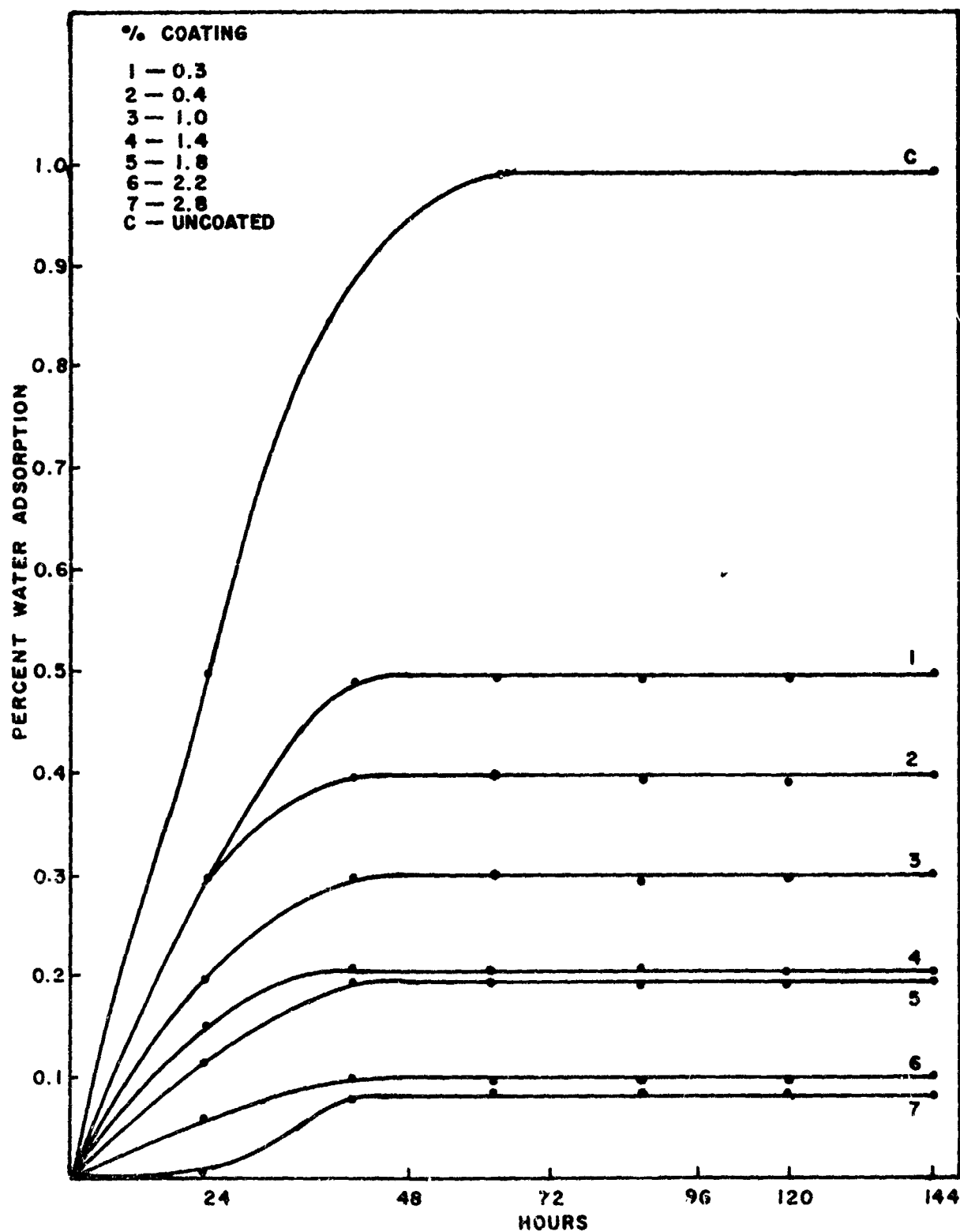


Fig 2 Rate of Water Adsorption of Parylene C-Coated AN (Prilled) at 52% R.H. (23°C)

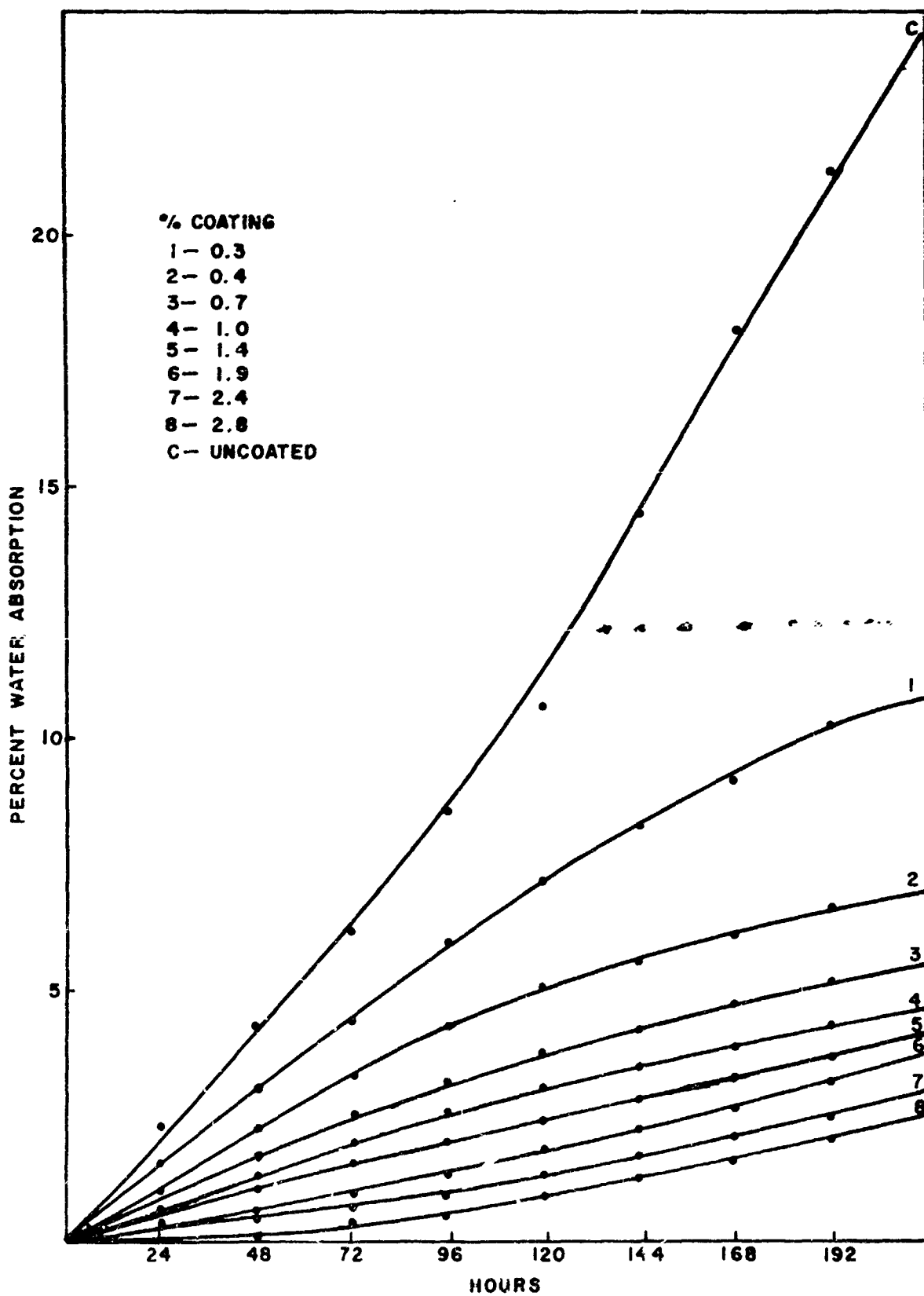


Fig 3 Rate of Water Absorption of Parylene C-Coated AN (Prilled) at 76% R.H. (23°C)

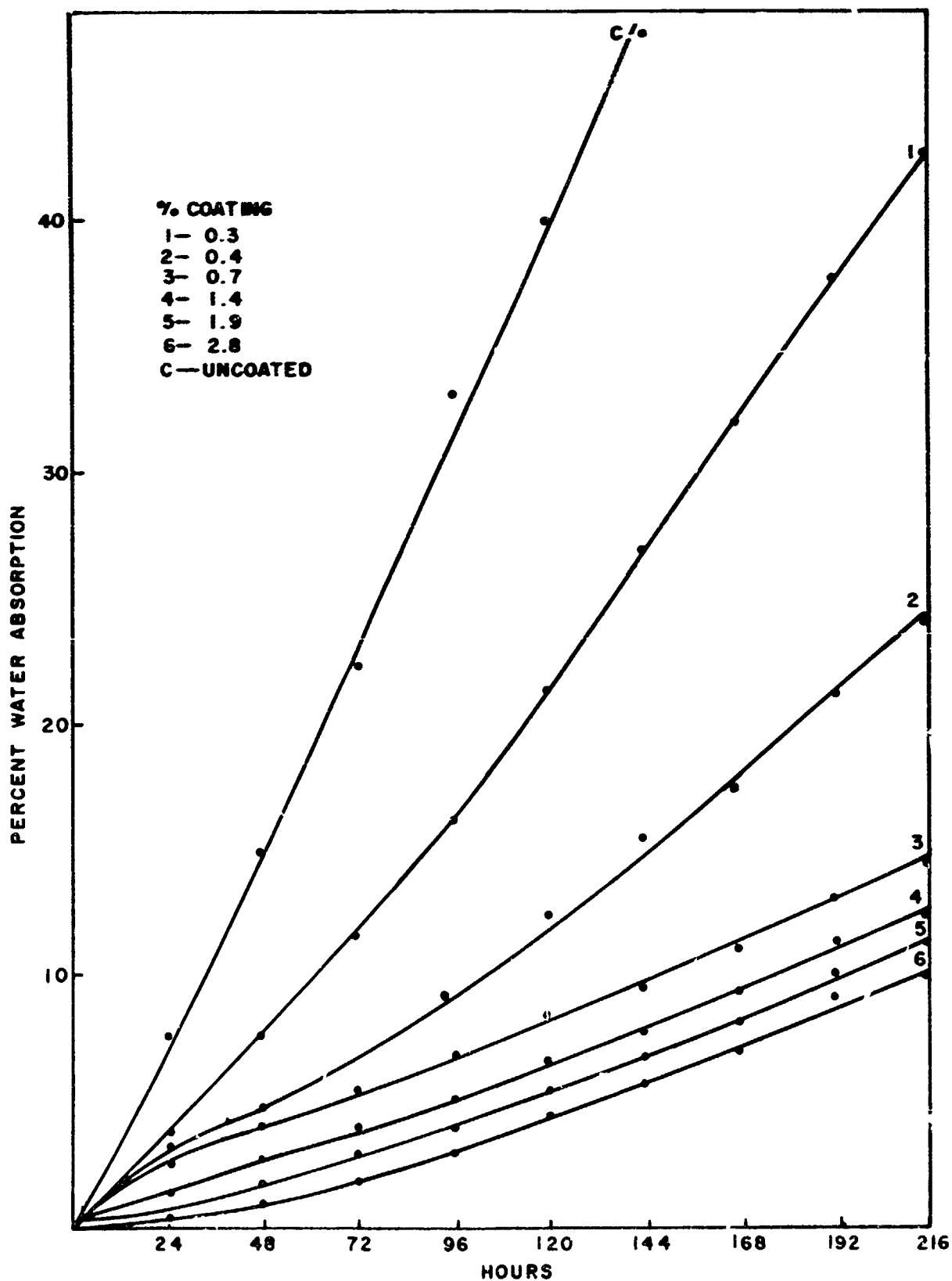


Fig 4 Rate of Water Absorption of Parylene C-Coated AN (Prilled) at 100% R.H. (23°C)

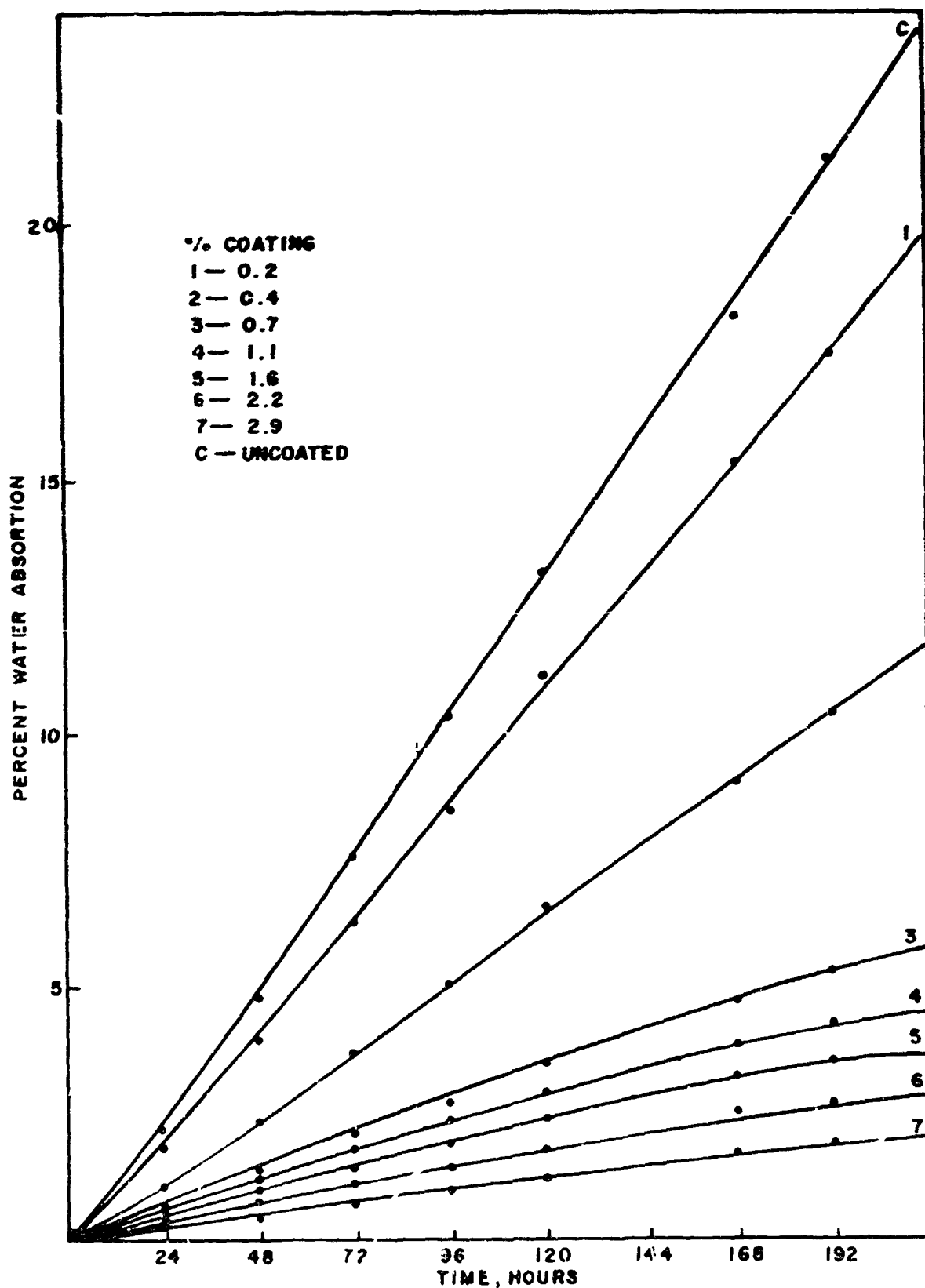


Fig 5 Rate of Water Absorption of Parylene C-Coated AN (Spherodized)
at 76% R.H. (23°C)

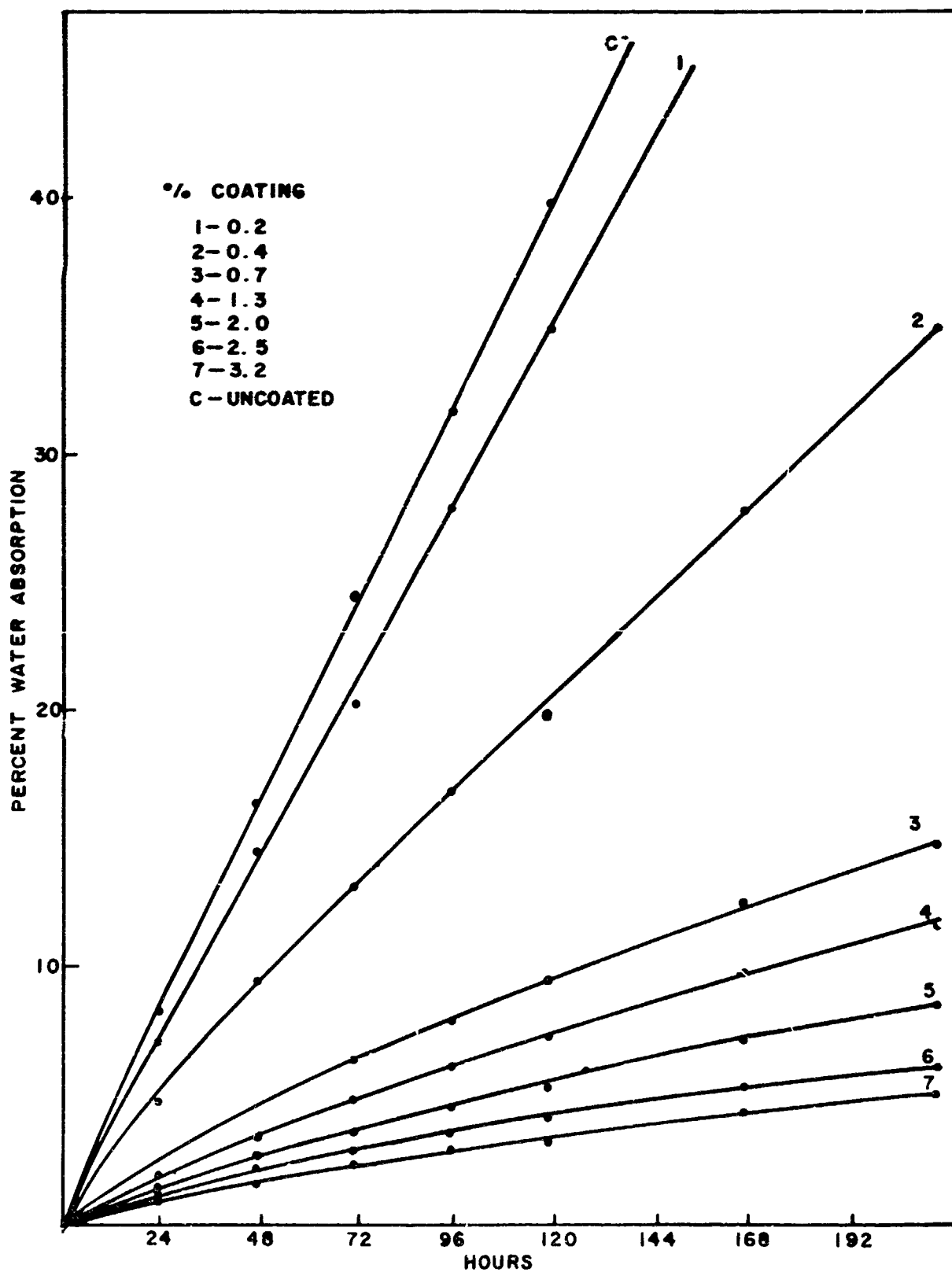


Fig 6 Rate of Water Absorption of Parylene C-Coated AN (Spherodized)
at 100% R.H. (23°C)

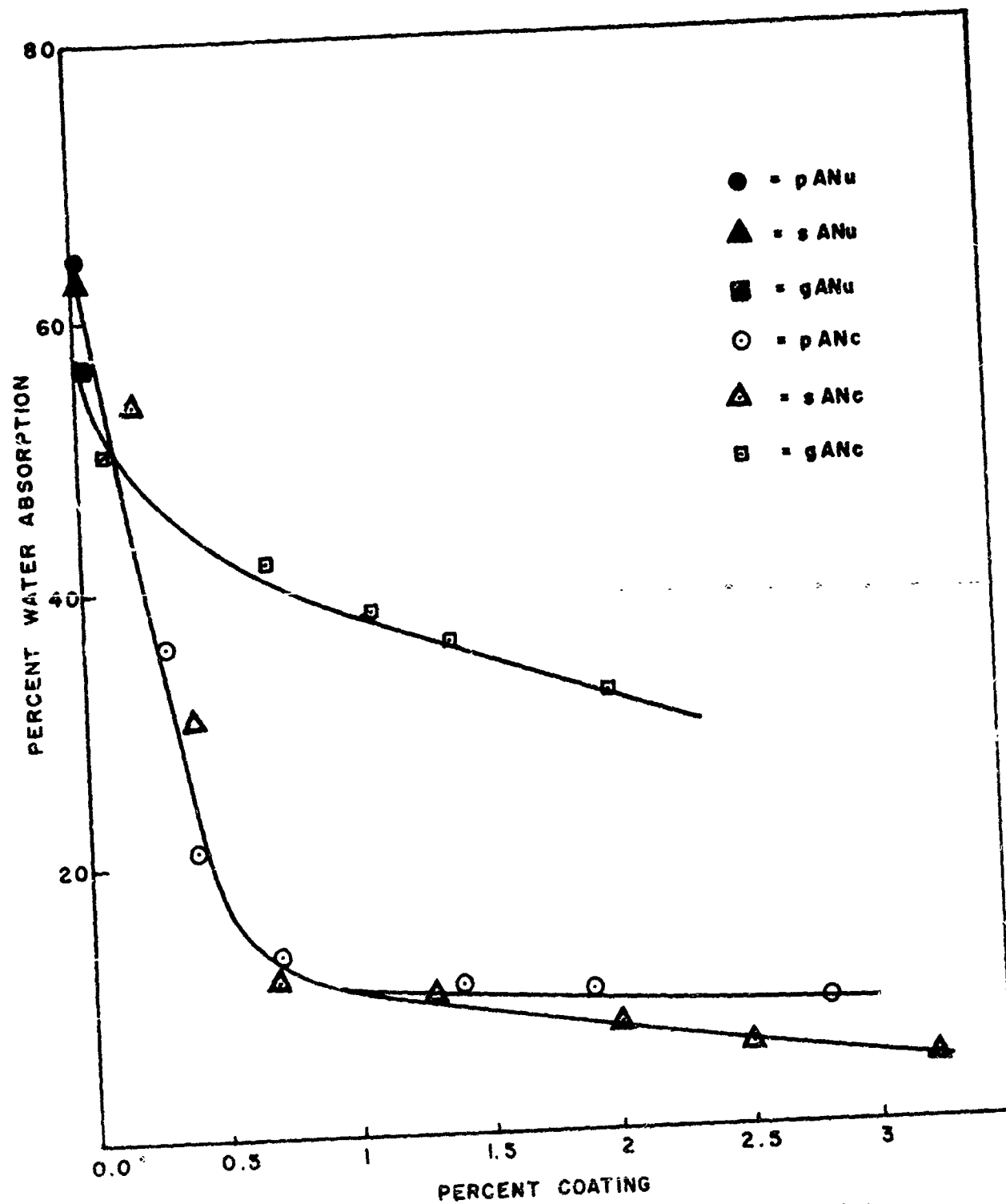


Fig 10 Water Absorption by AN Exposed to 100 R.h. for 192 hours
As a function of Thickness of Parylene C-Coating

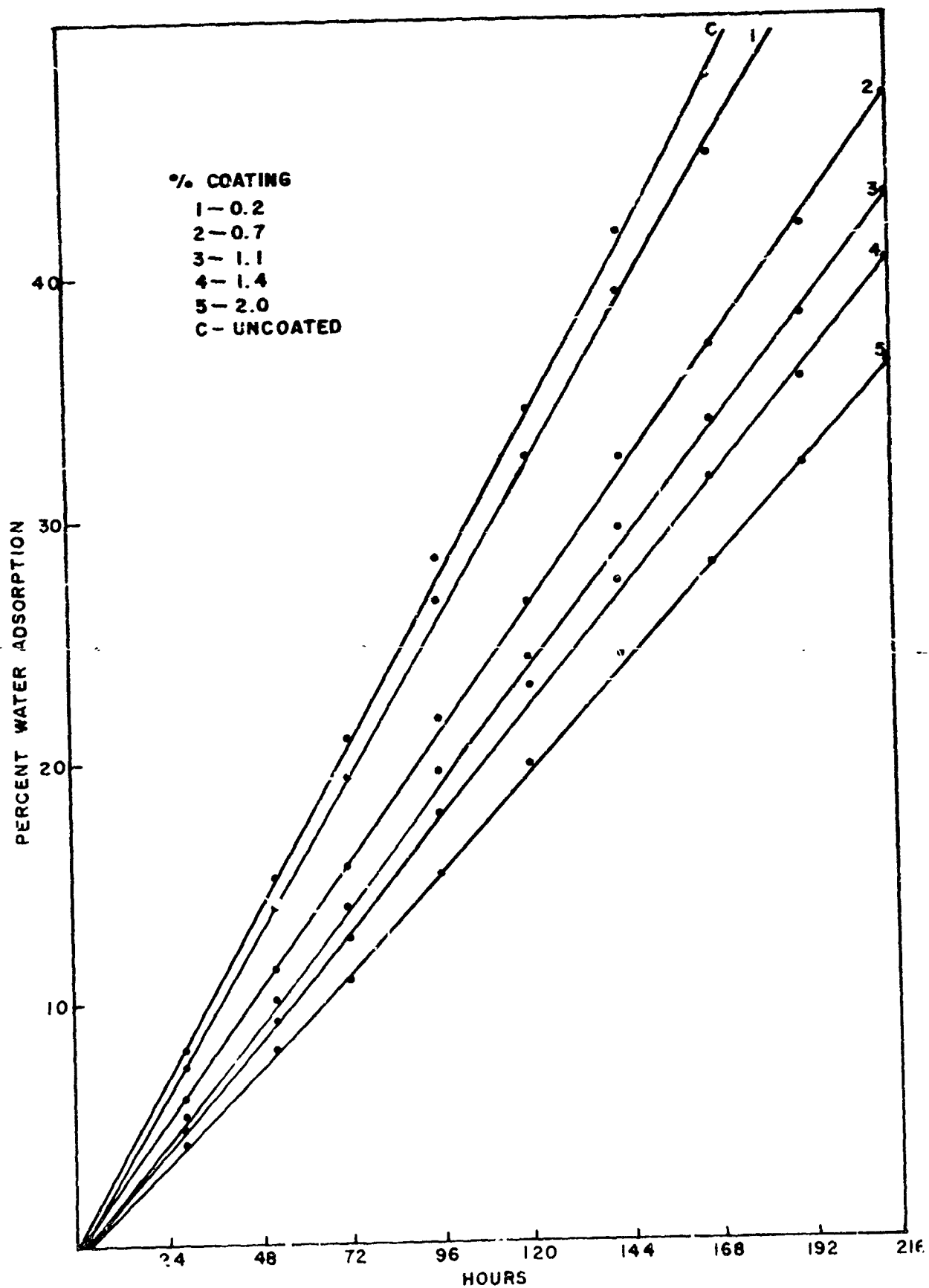


Fig 8 Rate of water absorption of Parylene-coated AN granules;
at 100 °F (23 °C)

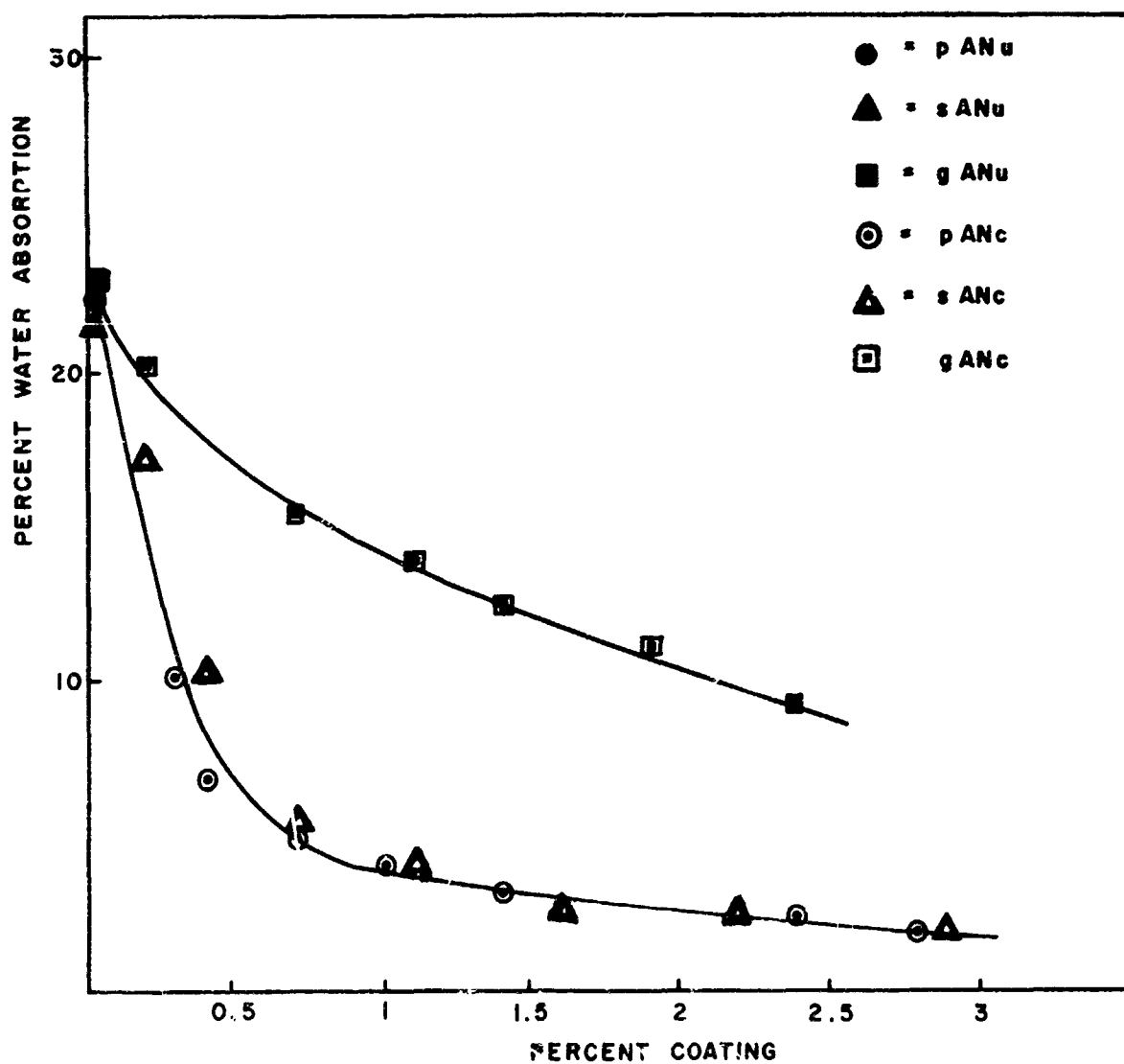


Fig 9 Water Absorption by AN Exposed to 76% R.H. for 192 Hours
As a Function of Thickness of Parylene C-Coating

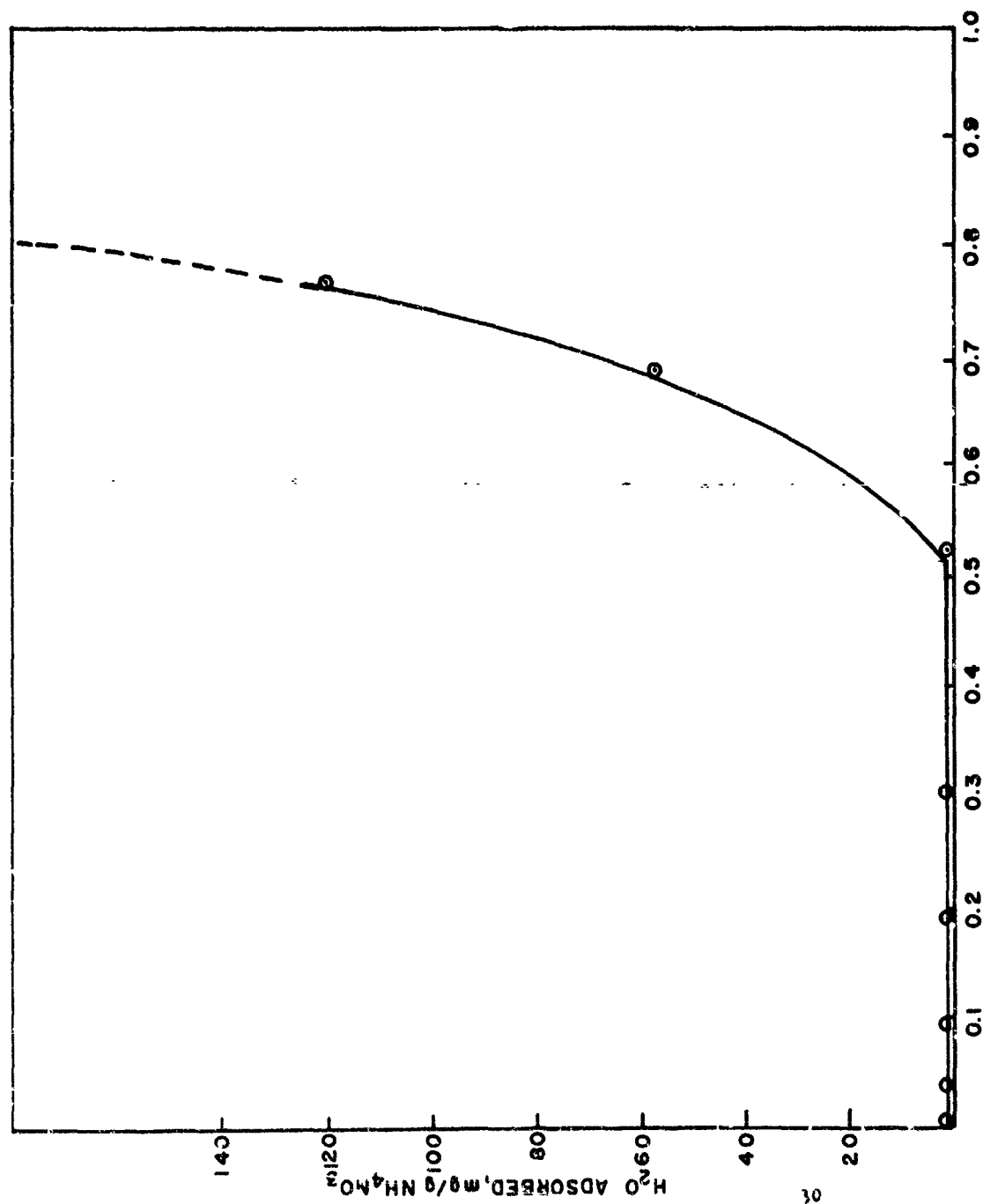


Fig 11 H₂O Adsorption Isotherm at 25°C on AN

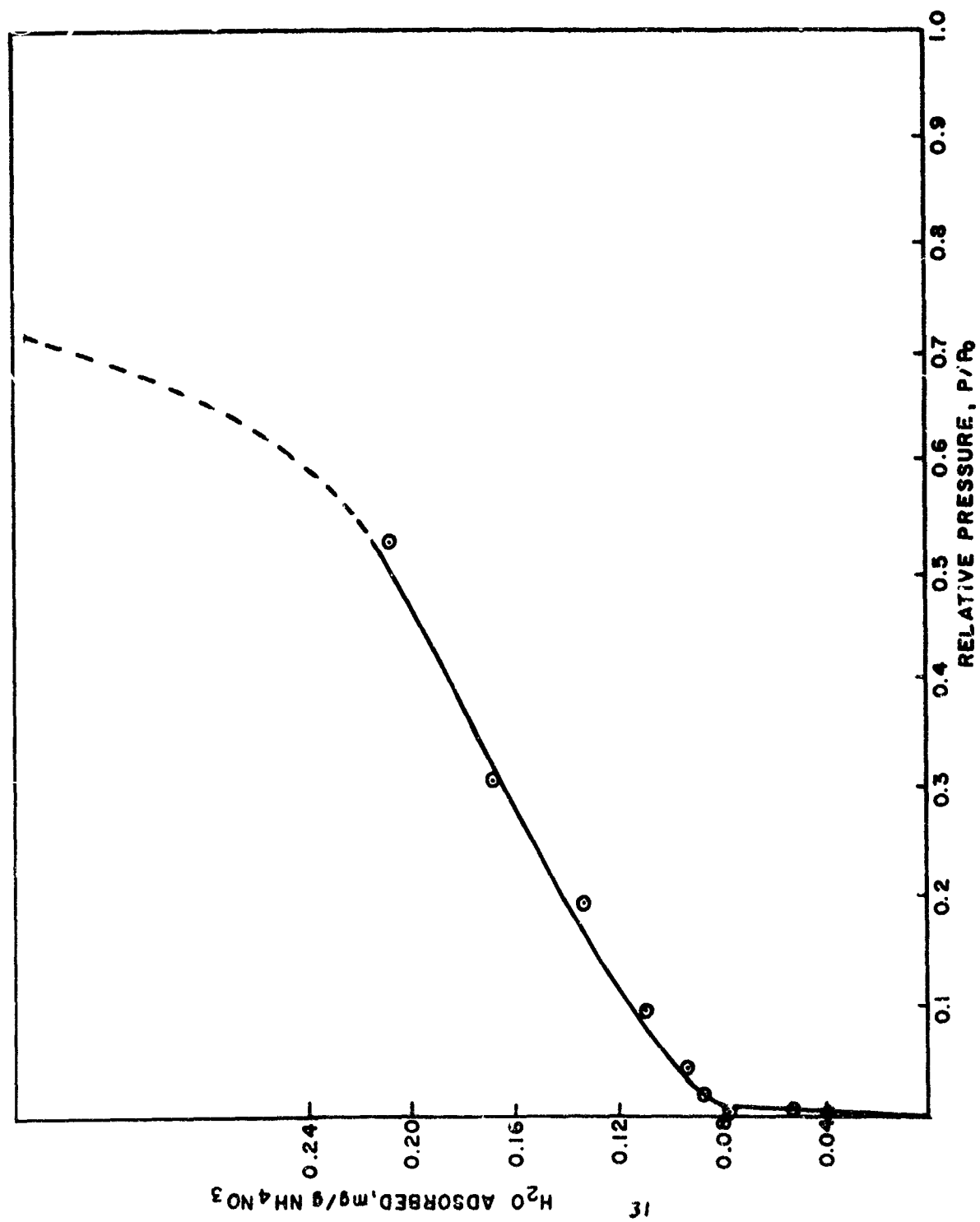


Fig 12 H_2O Adsorption Isotherm at 25°C on AN

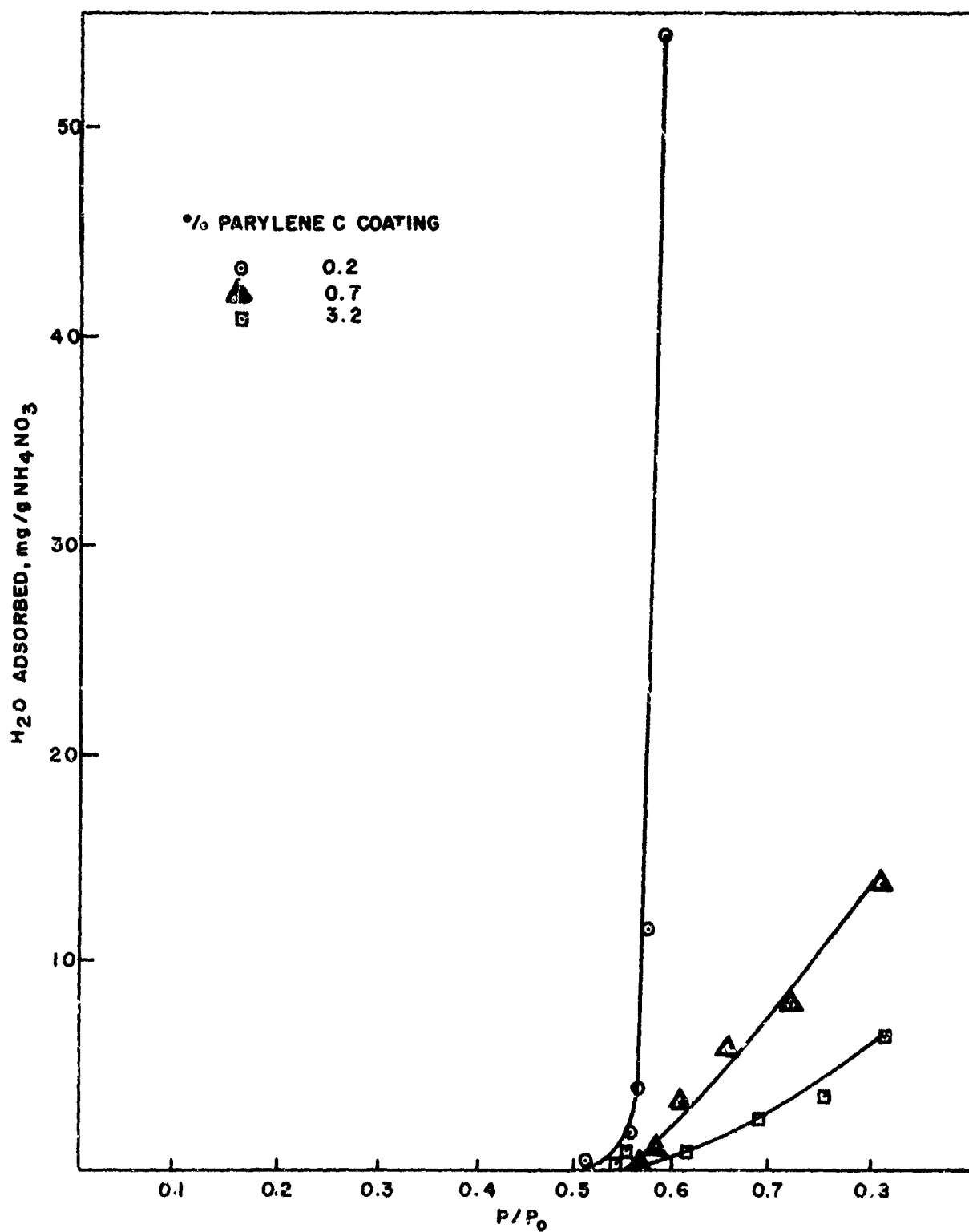


Fig 13 H₂O Adsorption on Parylene C-Coated AN

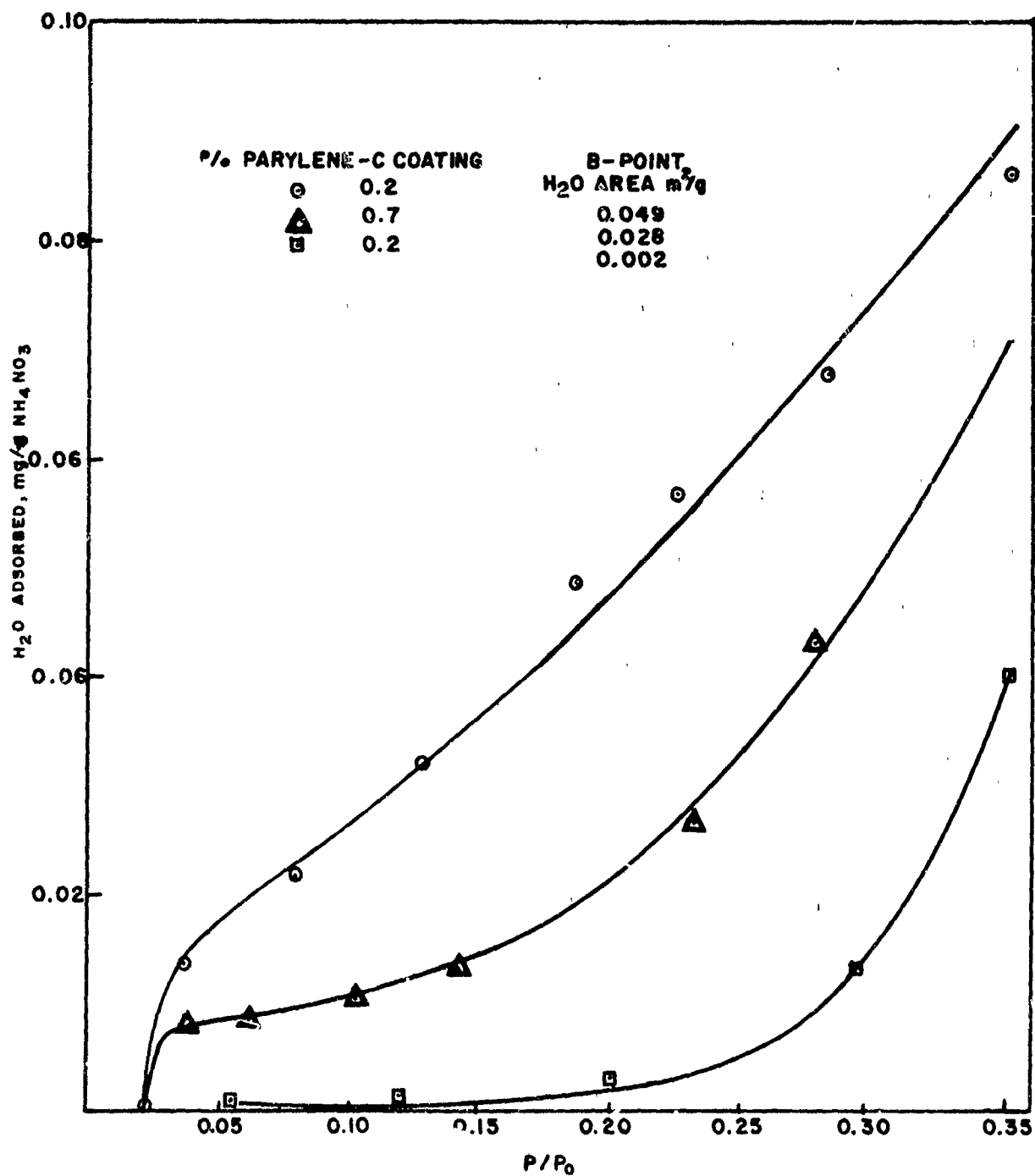


Fig 14 H₂O Adsorption on Parylene C-Coated AN