PDC SEARCH NO. 64-011

PDL-50915

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PREVENTION OF DETERIORATION CENTER
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POLYURETHANE COATINGS
USE AND PERFORMANCE

An Annotated Bibliography

Compiled by Hans Janecka

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Prevention of Deterioration Center
Division of Chemistry and Chemical Technology
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C-1291 Goodrich (B.F.) company, Akron, Ohio.
QUARTERLY ENGINEERING REPORT ON THE INVESTIGATION OF IMPROVED PAINTS FOR AIR SUPPORTED RADOMES, by Alexander G. Thomas.
Report no. 148DS206-330, from Dec. 1, 1953 to March 1, 1954. U.S. Rome air development center. T.N. 54-156. Contract no. AF 30-(602)-565.

Polyethyl acrylate (Hycar 4021), chlorosulfonated polythene (Hypalon), and the reaction products of polyesters with diisocyanates (Estane) appeared to be promising elastomers for paints for radomes exposed to weatherometer, ozonator, sunlamp, outdoor weathering and low-temperature flexing tests.

Vinylite VYHH, cellulose acetate butyrate, Amberlac 292—50% TS, and Geon 400X80 improved the strain resistance of Hycar 4021-base paints. A ratio of 75 parts rutile titanium dioxide to 100 parts Hycar 4021 was most effective in producing good pigment color.

The stain resistance of Hypalon-base paints was also improved by mica, the most effective ratio being 80 parts mica to 100 parts Hypalon. Rutile titanium dioxide also increased the resistance to discoloration and strain in Hypalon-base paints, but not in proportion to the amount added.

The low-temperature flexing properties of Hypalon were not improved by the addition of resinous materials. Those of Hycar 4021 were improved by the addition of Glyptal 2480, Duraplex C-45-HU 60%, and Arofene. The best ratio for obtaining good low-temperature flexibility and stain resistance in mixed Hycar-Hypalon paints was 75 parts Hycar 4021 to 25 parts Hypalon.

The addition of Hypalon cement to Estane I decreased stain resistance. The addition of Hycar 4021 to Estane I had no effect on stain resistance and decreased film strength, adhesion, and flexibility.

A blocking test was devised to test the dry painted surfaces under conditions simulating those of shipment and storage.

F-896 Eitel, M.
MEHRFUNKTIONELLE ISOCYANATE IN DER LEDERINDUSTRIE (Multifunctional isocyanates in the leather industry).
Das Leder, 4, 234-240. Oct. 1953.

Of the large number of synthetic polyfunctional isocyanates, only a few have important practical applications. Among these are the Desmodurs (Bayer), such as Desmodur T (a mixture of isomeric toluene diisocyanates) and Desmodur 15 (naphthalene diisocyanate). They react with all functional groups containing active hydrogen, notably with alcohols and amines, to give a variety of elastic 'polyurethan' products. They can be combined with alkyd (glyptal) resins, drying oils, phenolic resins, benzylcellulose, and vinyl acetate—vinyl chloride copolymers. They react best with hydroxyl-containing polyesters known commercially as Desmophens, e.g., Desmophen 1200 (a polyester made from 3 mol adipic acid, 3 mol butylene glycol, and 1 mol glycerol, hexanetriol, or other triol).

Among the many practical applications of these polyfunctional isocyanates are marine paints, wire enamels, lacquers for metal and wood, adhesives for metal, rubber, and synthetic leather, and finishes for textiles and paper. In the leather industry, they find use in tanning, impregnating, and finishing operations. Because of their greater affinity for amino than for hydroxyl groups, they are used for tanning in aqueous solutions. Aliphatic C_4-C_6 diisocyanates are particularly advantageous for this purpose. Isocyanate tanning can be combined with vegetable, synthetic, and mineral tannage. Isocyanate-tanned leather resembles suede leather. It is pure white, chemically neutral, soft, and resistant to light, acids, alkalis, hot water (75-85 C), gasoline, and oil. For economic reasons isocyanate tanning has not found large-scale practical application, but it is used for articles such as leather pants, wash leather, leather gloves, packings (washers), and oil filters. Solvents for isocyanates used in impregnating and finishing leather must not contain reactive hydrogen. Toluene, cyclohexanone, and butyl acetate are suitable. Pigments must be completely dry.

G-5946 COATING MATERIALS FROM POLYURETHANES.
Paint, Oil Chem. Rev. <u>113</u>(20), 33-34. Sept. 1950.

Cross-linked polyurethanes formed by the reaction of a diisocyanate and a dihydric or trihydric alcohol are useful in protective coatings. These compounds, which have high adhesion to glass, plastics, and light-metal alloys, are known in Germany by the trade names Desmophene and Desmodur. The properties of these resins vary with the alcohol or isocyanate employed; generally, a softer, more elastic coating having unusually high adhesion results when long-chain dibasic acids are used and the ratio of dihydric to trihydric alcohols is relatively high.

Urethane drying oils, produced by treating drying oils with a polyhydric alcohol and a diisocyanate, are water-resistant and difficult to saponify. They have good chemical resistance, good electrical insulating properties, are compatible with basic pigments, and are durable. Aromatic diisocyanates such as chlorophenylene diisocyanate and toluene diisocyanate give the best results. Aliphatic isocyanates such as hexamethylene diisocyanate produce oils that have greater elasticity but that dry slower. All of these oils are deficient in light resistance and gloss.

G-12171 Reilly, Charles B., and Milton Orchin.
PREPARATION AND PROPERTIES OF POLYURETHANE COATINGS. RAIN-EROSION PROTECTION FOR ALUMINUM.
Ind. Eng. Chem. <u>48</u>, 59-63. Jan. 1956.

The leading edges of high-speed aircraft are rapidly eroded by flight through moderate rainstorms. An aluminum panel specimen traveling at

500 mph through a simulated rainfall of 1 in. per hr shows considerable roughness after 5-10 min. Pitting sets in after 15 min and continues until the metal is completely eroded. In the search for strong, elastic protective coatings which can absorb the energy of rain drop impact by reversible elastic deformation, various polyurethan formulations were synthesized and tested. Preliminary trials indicate that polyurethan coatings prepared from poly(ethylene adipate) and 2,4-tolylene diisocyanate and crosslinked with ethanolamine remain unaffected under simulated rainfall long after comparable neoprene coatings have worn through.

The best results on Alodine 1200-pretreated Alcoa aluminum panels (24ST4) were obtained with coatings 0.010-0.015 in. thick, brushed on from acetone-chlorobenzene solution, air dried, and heat-cured at 120 C for 2 hr. Coatings prepared from 2,4-tolylene diisocyanate and polyethylene adipate 2600 in a ratio of 1.65 and sufficient ethanolamine just to equal the excess diisocyanate remained unaffected under a 1-in. simulated rainfall at 500 mph for 294 min. At this time, a small pinhole developed, but the coating showed no essential wear for 434 min. A neoprene coating lasted only 56 min under the same conditions, and untreated aluminum was badly eroded after 60 min. Although many of the polyurethan coatings developed pinholes earlier than 294 min, in no case was there any appreciable wear until long after neoprene coatings had worn through. On contact with the rain the polyurethan coatings formed a transparent, soft, shiny, and homogeneous surface.

G-12602 CORROSION RESISTANT LINING FOR SHIPS' OIL TANKS.
Engineer 201, 304. April 1956.

'Prodorfilm,' a polyurethan resin is particularly suitable for the lining of fuel tanks. It has the advantage over 'Prodor-Glas' in that it is cold setting. The prodorfilm lining consists of a series of coats of lacquer applied at intervals of 8 hr over a priming coat. Final thickness is about 0.005 in. Steel surfaces should be cleaned thoroughly to assure good adhesion.

Prodorfilm has been applied successfully to line the oil tanks of a number of British ships. It has also been tested in a special test apparatus in which actual service conditions occurring in an oil tanker are simulated. Two tanks, one lined with Prodorfilm and the other unlined are filled successively with crude and refined oil and sea water and the walls washed with hot sea water, while the tanks are given a rolling motion and the structure stressed causing part of it to deflect in a manner similar to that of the longitudinal and transverse bulkheads of a ship. The unlined tank suffered increasingly severe corrosive attack, whereas the Prodorfilm lining on the other tank remained intact and retained its original gloss. There was no sign of breakdown or corrosion and no evidence of any cracking of the lining owing to the panting movement of the tank sides. Total exposure time in the various test media amounted to about 1100 hr.

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G-12741 Steffens, Herbert G.
ISOCYANATE-RESIN-COATED GLASS CLOTH INSULATION.
Elec. Mfg., 57(1), 114-115. Jan. 1956.

An isocyanate-resin-coated glass cloth, manufactured under the trade name 'Isoglas,' shows promise as electrical insulation for continuous service at 150 C, i.e., between Class B and Class H temperature ratings. Its resistance to crazing is superior to glass cloth coated with silicone resins or other coatings. Superior adhesion between resin and glass fiber suggests wide application to various bias-weave, coated glass insulations. Isocyanate-resin-treated asbestos (Isobestos), glass sleeving, and laminated slot insulation are now in production.

PDL-30129 Princeton, University, Princeton, N.J. Frick chemical laboratory.
CHEMORHEOLOGICAL STUDY OF POLYMETHANE ELASTOMERS, by P.C. Colodny and A.V. Tobolsky.
U.S. Office of naval research. Technical report RLT-22. April 1957.

[Polymers, urethan, research, rheology]

PDL-30872 Cornell aeronautical laboratory, inc., Buffalo, N.Y.
SUMMARY REPORT ON THE RAIN EROSION OF AIRCRAFT MATERIALS, by Roy R. Lapp, Raymond H. Stutzman, and Norman E. Wahl.
U.S. Wright air development center. Technical report 53-185, part 3. Sept. 1956.

[Research, aircraft, rain erosion, coatings, elastomers, plastics, metals, laminates, ceramics, glass, neoprene, ethylene polymers, neoprene, polymethane]

The relative rain erosion resistance of different types of materials including coatings, elastomers, plastics, structural laminates, metals, ceramics, and glass was tested on the whirling arm tester, generally at 500 mph and 1 in. per hr simulated rainfall. Many of the tests were carried out on materials weathered under various climatic conditions.

A modified Gaco N-79 neoprene coating was the only solvent-type air-dry coating tested that gave satisfactory performance. Polyurethane materials tested in the form of sheet or coatings applied to standard glass-reinforced test specimens also offered good erosion resistance. Fluorinated ethylene materials showed poor resistance.

White coating materials tested included those based on alkyd enamels, vinyl, silicone, butyl, polysulfide, and chlorosulfonated ethylene elastomers. Of these, only coatings based on Hypalon alone or combinations of white pigmented neoprene and polyacrylic rubber merited further study.

Of the outstanding glass and ceramic materials tested, Corning Glass 1710 took 45 min to erode. The outstanding nonmetal was Alsimag 576 made of alumina, which lasted 420 min. The erosion resistance of standard test specimens of epoxy-glass laminates was 4 to 5 times that of similar laminates made with polyester resins. Neoprene-coated thin-walled laminates such as those used on hot air deiced radomes showed poor resistance to rain erosion.

PDL-31957 Mobay chemical company, St. Louis, Mo.
MONDUR - MULTRON URETHANE SURFACE COATINGS.
Second edition. [n.d.] 39 p.

[Chemical, urethan, coatings, isocyanates, polyester resins, chemical structure, formulation, application]

PDL-33223 U.S. Arsenal, Rock Island, Ill. Laboratory.
POLYURETHANE RUBBER BIBLIOGRAPHY.
Lab. no. 55-2988. Aug. 1955. 27 p.

[Bibliography, urethan, polymers, elastomers]

PDL-33689 MATERIALS OF CONSTRUCTION.
Ind. Eng. Chem., 50, 1426-1498. Sept. 1958.

[Review, bibliography, aluminum alloys, lithium, aircraft, ceramics, high temperatures, elastomers, butadiene, fibers, lead alloys, zirconium alloys, nickel alloys, plastics, coatings, stainless steel, ferrous metals, tin alloys, titanium, wood, wood preservatives, applications, textiles, welds, corrosion, high temperature]

PDL-34026 Mason, N.A.
PAINTS AND COATINGS FOR FLOORS AND DECKS.
Paper presented at the Building research institute, Research correlation conference on Field-applied paints and coatings, Washington, D.C., Dec. 3-4, 1958. 4 l.

[Review, coatings, floors, decks, urethan, concrete, emulsion]

PDL-35525 Cincinnati. University. Applied science research laboratory.
DEVELOPMENT OF A COATING FOR PROTECTION OF AIRCRAFT COMPONENTS AGAINST RAIN EROSION, by Jerome Ludwig and Kwang Sik Yun.
U.S. Bureau of Aeronautics. Contract NOas 56-666-d, progress report no. 6. August 1957.

[Progress report, aircraft, coatings, rain, erosionproof, polymers, urethan, formulation]

PDL-35719 Wells, Edward R., and others.
THE PROPERTIES AND APPLICATION OF URETHANE COATINGS.
Official Digest, 31, 1181-1210. Sept. 1959.

[Review, coatings (organic), polymers, urethan]

PDL-35738 Bieneman, R.A., E.J. Baldin, and M.K. Markoff.
STABLE PIGMENTED COATINGS SYSTEMS.
Ind. Eng. Chem., 51, 1387-1388. Nov. 1959.

[Coatings (organic), pigment, water, contaminants, urethan polymers, decompositionproofing, formulation]

Much of the instability of pigmented polyurethan coatings caused by adsorbed moisture and other reactive contaminants present in the pigments can be overcome by a slurry grinding technique. The pigments, enough solvent (xylene or toluene) to make a slurry, and an isocyanate (tolylene diisocyanate) are charged to a closed dispersion system, such as a ball mill, and intimately mixed until the residues have reacted with the isocyanate. The prepolymer then is introduced and the completed system is ground. Pigments and ingredients containing excessive moisture should be avoided as they react with isocyanate and build up dangerous carbon dioxide pressure in a closed system.

Four film-forming prepolymer systems containing different levels and types of isocyanate and varying hydroxyl-bearing components were studied. All these vehicles were stable under normal storage conditions when unpigmented, but unstable when pigmented by conventional procedures. Three paints were prepared for each pigment-vehicle (vegetable oil or polyglycol) combination: a control with no isocyanate, and identical paints containing 1 and 2 times the theoretical equivalent weight of isocyanate required to react with the water in the pigment. About 20 pigments were studied. Stability of the inorganic types was greatly increased by this treatment, whereas that of organic pigments showed little change.

PDL-36127 Griffith, J.R., J.E. Cowling, and A.L. Alexander.
LOW-HAZARD LININGS FOR STEEL FUEL STORAGE TANKS.
U.S. Naval research laboratory. Report 5384. Nov. 1959. 29 p.

[Tanks, storage, fuel, jet, steel, coatings (organic), interior, urethan, polymers, primer, coating (metallic), spray, aluminum, comparison, stainless, zinc]

The following types of organic coatings used as linings for petroleum fuel steel storage tanks were evaluated by immersion in water-aviation fuel blends: epoxy resins, polysulfide elastomers, phenolic resins, furan resins, polyethylene, vinylidine chloride-acrylonitrile copolymers, vinyl chloride-vinyl acetate copolymers, polyamides, zinc silicate, and urethans.

Properly formulated coatings of the urethan type were the most inert and also possessed the required physical properties. These coatings, however, must be applied from a solution of combustible and moderately toxic solvents to achieve ultimate properties. Nonflammable solvent blends were developed but with a sacrifice in coating properties, particularly water resistance. The urethans may be applied over one coat of wash primer (MIL-C-15328), but aluminum metallizing is preferred. The use of flame sprayed aluminum as a substrate doubled the coating life of several systems. Almost equivalent results were obtained with flame sprayed stainless steel, but costs were about 20 to 30 times higher. Flame sprayed zinc did not produce a suitable coating substrate; it accelerated coating failure in some instances.

Properly applied organic coatings of high inertness seal pores as large as 0.032 in. in diameter against pressures up to 200 psi. The maximum pressures expected in the bottom and lower walls of normal sized fuel tanks do not exceed 20 psi. Organic coatings, however, cannot be expected to seal defects occurring after the coating has been applied.

Corrosion in unlined steel jet fuel tanks varies depending on the grade of fuel stored. JP-1, JP-3, and JP-4 offer no corrosion protection. The viscosity of JP-5 is sufficiently high to deposit a thin preservative oil film on the steel surface.

The possibility of static spark discharge is a hazard in large ungrounded or inadequately grounded tanks. Organic coatings having high dielectric strength increase this hazard. Because of its low vapor pressure, JP-5 probably presents little hazard from static discharge. JP-4, however, presents an extreme hazard because its vapor pressure at normal temperatures creates an explosive vapor-air ratio. Static discharge hazards can be eliminated by installing supplementary conductors in the tanks.

PDL-36329 CHARACTERISTIC PROPERTIES OF POLYURETHANE PROTECTIVE COATINGS.
Corrosion, 15(12), 93-94,96. Dec. 1959.

[Review, urethan, coatings (organic)]

Urethan coatings may be prepared from nontoxic isocyanate resins in combination with polyesters and other hydroxyl bearing materials such as castor oil and its derivatives. Final coatings are obtainable as single package and as two-component systems. The former is handled the same as orthodox paints; the latter is made by blending just prior to application a polyester resin dissolved in suitable solvents (with or without proper pigments) with an isocyanate dissolved in dry solvents. The properties of the urethan vary with the type of polyester. Highly branched polyesters give rigid films of maximum chemical resistance; linear polyester produce films of excellent flexibility, abrasion, and water resistance. Data on hardness, abrasion resistance, impact, and chemical resistance of various types of urethan and conventional coatings are tabulated. Extended tests show that coatings produced with the two-component systems have high gloss and excellent resistance to weathering, water, humidity, abrasion, and weak solvents and chemicals, and are free from blushing and surface irregularities.

PDL-36472 Bailey, Maurice E.
POLYURETHANE COATINGS (CHEMISTRY AND FUNDAMENTALS).
Official Digest, 32, 197-202. February 1960.

[Coatings (organic), urethan, polymers, processing]

PDC Search No. 64-011

PDL-36473 Bieneman, Richard A., Edward J. Baldin, and Marko K. Markoff.
A METHOD FOR THE FORMULATION OF STABLE PIGMENTED COATINGS SYSTEMS BASED ON POLYURETHANE PREPOLYMERS.
Official Digest, 32, 273-390. Feb. 1960.

[Coatings (organic), urethan, polymer, pigment, formulation, contaminants]

PDL-36533 McGinnis, I.L.
POLYURETHANE COATINGS FOR WOOD.
Forest Products J., 10, 129-130. Feb. 1960.

[Coatings (organic), wood, urethan, polymers, properties, weathering]

Five types of polyurethan coatings including two 2-package systems and three 1-package systems are discussed. These coatings when properly formulated, produced, handled, and applied give a tough, clear, almost mar-resistant finish on wood. Polyurethans are 2 to 20 times more wear resistant than conventional finishes, have good resistance to tidewater immersion and to chemicals (except concentrated acids), high moisture vapor transmission rate, and outstanding adhesion to untreated wood, cement products, copper, and nickel. Disadvantages include a short pot life for the two-package systems, poor outdoor durability without an ultraviolet light absorber, tendency to yellow in outdoor weathering, only fair adhesion to steel, poor adhesion to oil coatings such as wood fillers, limited color range due to pigmentation problems, possible toxic effect of unreacted toluene diisocyanate, and higher cost than conventional type clear coatings.

PDL-36699 Akron. University. Institute of rubber research.
DEGRADATION STUDIES ON CONDENSATION POLYMERS, by Marvin A. Deisz, and Masao Ohta.
U.S. Signal corps. Contract DA-36-039-SC-74982, first quarterly report. For the period: Jan. 15 - April 15, 1958. [n.d.] 32 l.

[Urethan, analysis, polymer, decomposition]

PDL-36728 Damusis, Adolfas, James M. McClellan, Jr., and Kurt C. Frisch.
POLYETHER POLYOLS IN URETHANE COATINGS.
Official Digest, 32, 251-272. Feb. 1960.

[Coating (organic), urethan, polymers, properties, weatherproofing, waterproofing]

One- and two-component urethan coatings were prepared by reacting a series of nine polyether polyols (including simple and polymeric diols, triols, and tetraols) with tolylene diisocyanate. Polymerization conditions were controlled to yield isocyanate-terminated and hydroxyl-terminated intermediates with an ordered structure. Each isocyanate-terminated intermediate was then crosslinked by reaction with water, simple polyols, or hydroxyl-terminated intermediates to form cured coatings.

The flexibility of the coatings and their resistance to impact, abrasion, and solvents were affected by, and varied with, the equivalent weight, chemical composition, structure of the polyols, and crosslinking agents used. Coatings cured with water usually were harder and more resistant to solvents than were those cured with polyols, using the same isocyanate-terminated polymer as starting material. The presence of a tertiary amine nitrogen in the crosslinking agent accelerated the hardening rate of the coatings and imparted a unique combination of hardness, toughness, and impact resistance. Polyether urethan coatings appear promising for the following applications: clear varnishes for the protection of wood against exterior weathering or interior usage; moistureproof and decorative finishes for concrete; anticorrosive coatings for metals; and protective and decorative lacquers for rubbers, plastics, and leather.

Accelerated weathering tests of fifteen selected coatings (including isocyanate-terminated intermediates cured with water, polyols, or hydroxyl-terminated intermediates) applied in two thicknesses to a final dry thickness of 3 to 4 mils to maple and walnut blocks indicated no loss of gloss after 1000 hr of continuous exposure.

PDL-37274 RELATION OF MOLECULAR STRUCTURE AND PIGMENTS TO COATING PERFORMANCE.
Corrosion, 16(6), 32,34,37-38. June 1960.

[Coatings (organic), adhesion, structure, formulation, review]

PDL-38010 Scofield, Francis.
PROTECTIVE COATINGS.
Ind. Eng. Chem., 52, 879-880. Oct. 1960.

[Coatings (organic), review, bibliography]

PDL-38520 Bailey, Maurice E. and others.
CORRELATION OF PROPERTIES WITH STRUCTURE IN URETHANE COATING POLYMERS.
Official Digest, 32, 984-1001. July 1960.

[Coatings (organic), urethane, polymers, formulation]

A method for the systematic design of urethane coating formulations giving high quality films is presented. The investigation was made with an adduct coating based on toluene diisocyanate and castor oil or dehydrated castor oils. This type could be cured through both its diisocyanate and drying oil activity.

In these coatings, the energy of rupture of the free film is found to be a measure of the over-all quality. Arbitrary factors, R and S, which relate the energy of rupture to composition variables such as the hydroxyl number and unsaturation of the OH component, percent toluene diisocyanate, and NCO/OH ratio are defined. These factors serve in the design of formulations giving films of the highest quality.

Best mechanical properties are obtained with R is 80; maximum chemical resistance (determined by an empirical steam test), when R is 120 to 150. Coatings requiring both good chemical and mechanical properties should be designed with an R value of 80 to 120. Film properties are controlled predominantly by the urethane linkage, but oxygen linkages at the sites of unsaturation contribute in minor degree to the quality of the film.

PDL-39747 Griffith, J.R., and G.E. Rohl.
AN ISOCYANATE PRIMER-SEALER FOR MASONRY.
U.S. Naval research laboratory. Report 5580. Jan. 1961.

[Brick, cement, coatings (organic), primers, exterior, systems, sealers, acrylic, isocyanates]

Exterior masonry surfaces ranging from new concrete to severely weathered and previously painted concrete, brick, and glazed tile were painted with a reduced solids acrylic emulsion (Rhoplex Ac-33), with and without a tung oil-phenolic spar varnish (Fed. Spec. TT-V 119) or isocyanate primer-sealer. Isocyanate primer composition was (in % by wt) 25 isocyanate (a condensation product of trimethylolpropane and toluene diisocyanate), 20 xylene, 20 cellosolve acetate, 20 butyl acetate and 15 ethyl acetate.

One-year exposure data indicate that such acrylic emulsions are satisfactory on vertical surfaces only with proper priming sealing. Both the spar varnish and isocyanate primers are satisfactory, the latter is particularly good when penetration is desired. A longer exposure is needed to compare them. Horizontal surfaces, and surfaces interrupted by signs and drainpipes, should be carefully primed and painted; otherwise, early failure of emulsion paints is likely.

PDL-42293 Jaffee, Leonard D., and John B. Rittenhouse.
EVAPORATION EFFECTS ON MATERIALS IN SPACE.
California institute of technology, Pasadena. Jet propulsion laboratory.
Technical report 32-161. Oct. 1961.

[Vacuum, temperature, metals, semiconductors, ceramics, polymers (organic)]

Sublimation of inorganic materials in the vacuum of space can be predicted accurately from knowledge of their vapor pressures and, for compounds, of their free energies. Among the elements, cadmium, zinc and selenium are readily lost near room temperature and magnesium at elevated temperatures. Selective loss at individual grains and at grain boundaries can produce some surface roughening. Evaporation rates of low-molecular-weight single-component oils can also be calculated from vapor pressures; most are rather high. Polymers lose weight in vacuum by decomposition; nylon, acrylics, polysulfides and neoprene show high decomposition rates near room temperature. Many other polymers, including polyethylene and isoprene, are stable to high temperatures in vacuum. Engineering properties are, in general, little affected in vacuum unless appreciable loss of mass occurs. The temperature at which various amounts of thickness per year will be lost from a surface are tabulated for 36 elemental metals and semiconductors. A table gives an estimated order of merit for behavior of 50 polymers in vacuum, together with temperatures for an estimated weight loss of 10% per year.

PDL-42527 Mattice, James J.
THE DECOMPOSITION OF ORGANIC RESINS AT HIGH TEMPERATURE IN A VACUUM ENVIRONMENT.
U.S. Wright air development division. Technical report 60-773, p. 107-116. July 1961. [In: Coatings for the aerospace environment].

[High temperature, vacuum, coatings (organic), resins, structure, vinyl, polyurethane, silicone, decomposition]

PDL-43051 Thompson, J.C., R.K. Logan, and R.B. Nehrich.
INVESTIGATION OF SONAR DIAPHRAGM COATINGS.
U.S. Navy electronics laboratory, San Diego, Calif. Research and development report 1026. March 1961.

[Sonar, coatings (organic), urethane, polymers, steel, sea water, marine, atmosphere]

Nineteen commercially available coating materials were tested for use on sonar equipment, particularly sonar diaphragms constructed of corrosion susceptible 5% chromium steel. Test coatings included metals, plastics, ceramics and elastomers. Requirements were elasticity to withstand diaphragm vibration, resistance to sea water and salt atmosphere, and air drying and adhesive capabilities. A polyurethane product, Laminar X-500, successfully passed all tests; when properly applied, it effectively protects underwater equipment.

PDL-43688 Foulon, A.
REAKTIONSLACKE ZEICHNEN SICH DURCH BESTE HAFTFÄHIGKEIT AUS (Reaction lacquers distinguish themselves by superior adhesion).
Wochbl. Papierfabrik, 90, 248,250. March 1962.

[Coatings (organic), adhesionproof, formulation, foreign]

'Reaction lacquers' are defined as originating on a substrate by a chemical reaction between the components of a synthetic lacquer vehicle (binder), such as the isocyanate and polyester components of formulations available commercially under the trade names 'Desmodur' and 'Desmophen', respectively. Alternatively, 'Desmodur' can be combined with other hydroxyl-bearing components, such as alkyd formulations available under the trade name 'Alkydal'.

Reaction lacquers can be formulated to give either air-drying or oven-drying (baking) types of coatings. Both types have excellent pigment-binding properties and superior adhesion to a variety of substrates, including ferrous and nonferrous metals (such as aluminum and zinc), plastics, glass and porcelain. Solvents with reactive groups, as well as water, should be avoided. Suitable catalysts accelerate the drying time of air-drying lacquers and lower the baking temperature of oven-drying formulations (from 160 to 180 to 125 to 140 C).

Outstanding characteristics of reaction lacquers include permanent adhesion and elasticity, abrasion resistance, high dielectric properties, low flammability and excellent resistance to weathering, solvents and chemicals. The addition of plasticizers may impair solvent resistance but improves adhesion and elasticity. Passivating pigments provide corrosion resistant coatings.

PDL-45927 URETHANE PROTECTIVE COATINGS FOR ATMOSPHERIC EXPOSURES.
Materials Protection, 1(9), 95-99. Sept. 1962.

[Coatings (organic), urethane, polymers, weathering, chemicals, review]

PDL-45944 Motorola, inc., Chicago, Ill. Military electronics division.
CONFORMAL COATINGS FOR PRINTED CIRCUIT ASSEMBLIES, by Anthony J. Beccasio.
U.S. Army signal supply agency, Fort Monmouth, N.J. Standards engineering division. Contract DA-36-039-sc-89136, first quarterly report. [n.d.]. [For the period: July 10 - Oct. 31, 1961]

[Printed circuits, coatings (organic), laminates, storage, humidity, silicones, urethane resins, epoxy resins, progress report]

PDL-46134 Motorola, inc., Chicago, Ill. Military electronics division.
CONFORMAL COATINGS FOR PRINTED CIRCUIT ASSEMBLIES, by Anthony J. Beccasio.
U.S. Army signal supply agency, Fort Monmouth, N.J. Standards engineering division. Contract DA-36-039-sc-89136, second quarterly report. [n.d.]. [For the period: Nov. 1961 - Jan. 1962]

[Printed circuits, coatings (organic), laminates, storage, humidity, silicones, urethane resins, epoxy resins, progress report]

PDL-48565 Conway, J.S.
A BRIEF LOOK AT POLYURETHANE COATINGS.
Materials Protection, 2(7), 44,46. July 1963.

[Urethane polymers, coatings (organic), foams, review]

PDL-48613 CHEMICALLY CURED COAL TAR COATINGS FOR ATMOSPHERIC EXPOSURES.
Materials Protection, 2(7), 92-96. July 1963.

[Coatings (organic), coal tar, epoxy resins, urethane resins, corrosion-proof, review]

Two-packaged coal tar epoxy (both amine and polyamide cured) and coal tar urethane coatings were examined as to formulation, methods of mixing and application, and chemical and physical properties. They can be air sprayed to dry film thicknesses of 5 to 15 mils on surfaces, preferably sandblasted, with a single pass and to > 30 mils on the vertical with an airless gun. They can be applied to ferrous metals, to wood with ≤ 5% moisture content and to properly treated galvanized, aluminum or concrete surfaces. Adhesion is excellent, and they can be formulated to any degree of hardness. Abrasion and impact resistance are good to excellent; impact resistance may decrease with age. Resistance to weathering, neutral salts, salt or fresh water, and petroleum products is excellent. Resistance to aromatic solvents is fair to good but inferior to that of cold cured epoxies. Resistance to ketone-type solvents, oxidizing agents (e.g., nitric acid), and lower aliphatic acids (e.g., acetic acid) is poor. Coatings are resistant to 300 F but quickly fail by embrittlement at > 350 F. Storage life varies from 6 to 24 mo; pot life from < 1 to 8 hr at 75 F, depending on formulation, mass or volume, and temperature. The ratio of base material and curing agent may vary from 20 to 1:1. With epoxies, continued exposure to amines and resins can cause dermatitis; urethanes are nontoxic. The coatings are black but they may be overcoated with almost any color, using acrylic or chlorinated rubber materials.

PDL-49174 Izzo, C.P.
EVALUATION OF MATERIALS FOR OUTDOOR FINISH SYSTEMS.
Machine Design, 36(15), 197-199. June 1963.

[Coatings (organic), exterior, metals, weathering, chemicals, comparison, epoxy polymers, alkyds, acrylics, vinyl polymers]

Steel panels primed with a modified epoxy surfacer and sprayed with 2 1-mil coats (cured) of 5 different finishes were subjected to hardness tests, gloss measurement before, during and after 1000-hr Atlas Weather-Ometer exposure, and tests for resistance to corrosion (100 hr in 5% salt fog at 90 F), moisture (100 hr at 100% RH and 110 F), acidic vapors (5% hydrochloric, nitric and acetic acids at 75 F), vapor from 5% ammonia solution at 75 F, abrasion, cracking during bending over a 1/8-in. diam conical mandrel, impact (Gardner drop ball), and immersion in various chemicals including insulating oils and synthetic lubricants. All specimens were preaged for 168 hr at 50 C.

Acrylic lacquer gave the best gloss retention. Vinyl and acrylic finishes were equally good in all environments except ammonia vapor in which the acrylic developed No. 4 blisters while the vinyl was unaffected after 158 hr. Heat fusion of vinyl particles into a continuous film makes the coating less permeable than the solvent-drying acrylic lacquer. The vinyl was most resistant to wear followed in turn by the acrylic and the alkyd. The flexibility of the alkyd coating made it superior in deformation tests. An experimental epoxide enamel (peracetic acid-type epoxide ester) was best in chemical resistance.

PDL-49978 Traeger, R.K.
THE EFFECT OF RADIATION ON THE MECHANICAL PROPERTIES OF POLYMERS; BIBLIOGRAPHY.
U.S. Atomic energy commission. Office of technical information, Oak Ridge, Tenn. TID-17351. Sept. 1962.

[Polymers, elastomers, rubber, cellulose, mechanical properties, radiation (electromagnetic), radiation (corpuscular), bibliography]

PDL-50766 Hill, H. Earl.
MEASUREMENT OF ADDITIVE EFFECTIVENESS IN URETHANE COATING DEGRADATION STUDIES.
Official Digest, 36(468), 64-68. Jan. 1964.

[Urethane polymers, coatings (organic), additives, degradation]

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