CONVERTING WITH WATER BASED ADHESIVES AND PRIMERS

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ABSTRACT

It is essential that we conserve petroleum since this is the basic feedstock of the petrochemical industry. This paper describes alternate sources of energy and feedstock and shows how water based adhesives and primers conserve petroleum.

I want to talk about petroleum because we are running out of it. I want to talk about energy because in creating energy we are using up our supply of petroleum. And I want to discuss water based adhesives, primers and coatings because they are here today, for use on existing equipment and can help in conservation efforts.

Petroleum first, and here I want to take a flight in fantasy.

Wouldn't it be wonderful if the whole earth were filled with oil instead of whatever it is filled with. This would represent a reserve of some 6.79 times 10^{21} barrels of oil, that is 6.79 followed by 21 zeros or 6.79 sextillion barrels.

The population of the world is using oil at a rate of about 19.5 billion barrels per year. At this rate, the earth would be pumped dry in 348 billion years. Since the rate of use of oil is increasing rapidly we might have to start sucking oil out of some nearby planet in about 100 billion years.

Of course this is silly. Oil is really found in a layer which seems to be some thousands of feet beneath the surface of the earth and is generally about 500 feet in depth or thickness.

Again, wouldn't it be wonderful if there was a pool of oil encircling the earth and it was 500 feet thick. It would contain 488 times 10^{15} barrels or enough to last us 25 million years, or if consumption doubled, 12 million years.

To be realistic, oil is found in pools which are as much as 500 feet in thickness, but there are very few pools and they cover only a fraction of the earth's surface.

I have seen world reserves estimated at about 21 times 10^{11} barrels or about a 100 year supply. If our usage doubles, we may have only 50 years left.

As best I can interpret the figures this reserve includes oil sands and oil shale and oil which must be extracted by special means such as steam. Since we are running out and future oil will be much more difficult to extract, the price of oil can only go up from now on.

Where is all this oil going? The Federal Energy Commission publishes a monthly energy review from which we can extract the figures on this pie chart. The refineries in the U.S. produce 18,470,000 barrels per day. This breaks down into Motor Gasoline which consumes 38.5%, the big user. This is followed by Fuel Oils 35.5%, a group which includes diesel fuel, home heating oil, and oil for producing electricity. Jet Fuel accounts for 5.5%. Natural Gas Liquids at 9.5% includes ethane, liquified petroleum, propane and butane. Other at 11%, includes heavy oils, waxes and asphalt.

Somewhere in these figures and from our natural gas production are the 559,000 barrels per day that go into the petrochemical industry to make just about all the plastics, synthetic fabrics, and the plastic packaging materials we use, including synthetic adhesives.

These few barrels per day are but 3% of our refineries' output. The important point is that as we run out of crude oil, and of natural gas at an even faster rate, we run out of the raw materials for nylon, polyester, polyethylene, polypropylene, poly just about everything.

Well, enough of this doom and gloom. If we understand the facts and begin to act in an intelligent, purposeful way, the future looks a bit difficult to me, but I am sure we will make it.

We need to act in two areas; energy and feedstocks. We need new sources of both. Let's start with energy.

We need first of all to conserve energy and I feel that most of us are way ahead of our political leaders in facing facts here.

Of the new sources of energy, nuclear energy seems best to me. It is a shame that we can't trust it to be completely safe, and it is insane that we can't safeguard it's by-products so that we don't have to live in fear of war or terrorism.

Solar energy is expensive to install but the source of it's power is compelling. It doesn't seem to be wearing out and it is free. Solar panels can be used for heating and cooling and for hot water. Every home, every building could produce its own. The sun's energy can be converted into heat, or through solar cells which are being developed, directly into electricity. And there is the synthetic leaf which uses a process like natural photosynthesis to produce tiny electrical charges. These are as yet so small they are hard to measure, but scientists are working on it.

Hydroelectric power fell off last year during the drought. I understand that the aluminum companies in the Northwest which use huge amounts of hydroelectric power, were allowed to start up again in Mid-January.

Geothermal energy and ocean thermal energy take advantage of the heating and cooling at various levels under the earth's surface. The thermal energy locked up in the oceans is tremendous but again, is expensive to tap. Hot water and steam deposits are being used now on a pilot scale to produce electricity.

The wind is a beautiful source. I do some sailboating and can attest to it's power, at times.

I think coastal regions should take more advantage of the tides. Perhaps the cost of installing the machinery is still too high. But, in a place like the Bay of Fundy, I should think they could release enormous energy. Ocean waves could also be used.

For the inventors in the audience the Energy Research and Development Administration can grant you money to pursue any good idea for creating more energy. Thus far they have received about 4,000 ideas, screened more than 3,000 and recommended 22 for more consideration. Don't send them your idea for a perpetual motion machine, they have already had thousands of them. Scientists at the National Bureau of Standards help in the selection process.

There are lots of alternative sources of feedstock both to produce electrical energy and to supply petrochemical plants.

Coal can be used to conserve our oil supplies or through gasification, to produce chemical feedstocks. And Mobil Oil has a new process for converting coal into methanol and methanol into gasoline. But it is expensive and would raise the price of gas to well over a dollar per gallon.

Biomass conversion is the use of plants and human and animal wastes to produce oil and gasses. If the process works and is economical, there is enough Biomass available in the world to supply all of our needs.

Along similar lines, Combustion Equipment Associates has built a plant in Brockton, Mass. to convert municipal garbage into a powder which can be used in electric power plants instead of fuel oil. Many cities are going for this idea because it is a single solution to many problems. It saves fuel, it gets rid of garbage, it does not pollute the air, and it saves money for the cities.

The feedstock that appeals to me most is Euphorbia lathyrus, the plant that oozes out a latex that can be converted into crude oil. This hardy plant grows well in arid desert areas.

The whole plant is crushed, placed in solvent to extract the oil, and the distilled oil can then be refined in present refineries. An acre of these weeds produces 10 or more barrels of crude per year. An area the size of Arizona would produce about 10% of the U.S. demand for crude oil. When I retire to Arizona I think I'll plant a few acres of Euphorbia lathyrus.

Over the past few months I have studied what people are saying about energy and feedstocks and it seems that as the cost of oil rises other sources will become more attractive and begin to come on stream. The dislocations we may have to endure in the changeover process I leave to our politicians to argue about.

As technical and professional people, all of us here have a high degree of consciousness about the subject, and are ready to use all of our innovative skills to help solve the problems we face. In our own small way we believe that our Company is helping.

The first idea we had some years ago had to do with conservation of the ecology. We felt that water based adhesives and coatings could be used without polluting the air or the contents of packages. Since 1973 it has been apparent that the water based concept is on the right track in conserving energy and particularly petrochemicals.

The first point is that water based materials are used in extremely thin layers. To illustrate just how thin a film we are talking about, we have gathered some coverage figures for a variety of adhesion jobs.

The abrasive grit sponge is used in household scouring like steel wool. It has a thick layer of adhesive and grit on one side and is sponge on the other. The adhesive used in covering the sponge with abrasive has to fill the holes in the surface and then form a thick film into which the coarse grit particles can sink and become partially embedded. Adhesives for bonding flock are in this same high use area (50,000 grams per ream, or 179 grams per square meter).

The adhesive for carton closure or sealing the flaps of corrugated cases has to bridge a large and often uneven gap. Pretty high consumption here (9,000 grams per ream, or 32 grams per square meter).

The adhesive for laminating thin metal foil to paper is applied to the smooth, non-porous foil. It contains fluorides which chemically attack the foil and to a mild degree, the paper. We see that these factors allow far less to be used. (400 grams per ream, or 1.4 grams per square meter.)

In bonding two packaging films together with a conventional urethane adhesive it is possible to use as little as ½ dry pound per ream. But generally the coverage is 300 to 500 grams. (About 1 gram per square meter.)

By comparison, water based adhesives for film to film and film to foil, are used in minute quantities, forming a sort of molecular bridge between two smooth but chemically reactive surfaces. (10 grams per ream, or 0.036 grams per square meter.)

In comparing film lamination done with solvent type adhesives and water based adhesives, the conservation of petrochemicals is considerable.

The solvent based adhesive at 25% solids uses 1360 grams per ream of solvent and 450 grams per ream of solids. The total is 1810 grams of material that is derived from oil or gas.

The water based system at 2½% solids uses no solvent and but 10 grams per ream of solids.

If we assume a very large and fast converting machine runs one ream per minute for 24 hours, this machine uses up 5,471 pounds of solvent type, compared with only 32 pounds of water based adhesive.

The second point is that the drying of water based adhesives and coatings is relatively easy.

We are talking about materials at low solids which are applied at low coating weights, Unlike latex and emulsion products, these dispersions release their water rapidly. We do, however, have to get rid of the water.

In looking at the calories required to evaporate one gram of various solvents, it is about three times as hard to evaporate water as isopropyl alcohol.

If we have a urethane adhesive in a mixture of isopropyl alcohol and hexane at 25% solids and apply one dry pound per ream, then we must evaporate three pounds of the solvent mix. This takes about 225,000 calories.

If we use a water based adhesive at 2.5% solids and lay down one wet pound per ream, it takes about 270,000 calories to dry.

It turns out that in practice the water based and solvent based materials are very similar in drying characteristics. Many converters use a bit more drying with solvent types to be sure no odor is trapped.

There have been some water based materials which had to be applied at a rate of three or four wet pounds per ream. These have not been widely accepted as they stretch the drying capacity of much of the equipment now in use.

Our water based materials conserve petrochemicals, require no additional energy to dry, and are of course non-polluting.

Some of the water based materials are used for bonding film to film and in the minute quantities which we apply we find that films must be responsive chemically to the bonding agents.

If the film to be bonded does not present us with the reactive sites which we are looking for, we can treat with corona discharge.

The adhesive is applied and dried.

We marry to another chemically reactive or attractive surface. Heat and pressure are used to force the chemical linkages to take place.

Films which are reactive without corona treatment usually contain chloride groups and include PVC and all saran coated surfaces.

Films which respond to corona are polyethylene, polyester, nylon, Aclar, Surlyn, EVA, plain cellophane and even paper.

The one film that does not respond well is polypropylene.

I agree with the theory that when corona discharge treatment is effective, it creates free radicals which immediately oxidize giving us carbonyl groups to link up with.

Bonding seems to be between carbonyl groups or between chloride groups or carbonyl to chloride groups.

When the adhesion process is working properly the two surfaces are in a sense, zipped together.

The functional groups on the films are like teeth that have been fit together. And the more linkages of this kind that are present, the better the bond seems to be, and the better the resistance to water, oil, fat, heating, freezing, acids and solvents.

When some of the teeth are missing or when the adhesive is not able to cross link them, we get gaposis. Things begin to fall apart.

The best bonds to chemically reactive surfaces are formed when the adhesive is a long chain molecule with many functional groups such as acrylic, amide, amine, carbonyl, carboxyl, hydroxyl, isocyanate, nitrile, vinyl and so forth. We choose polymers which can cross link to the surfaces with the application of heat and pressure such as is offered on a laminating machine.

Here, heated nip rolls are usually run at about 200 to 220°F (95°C). In extrusion coating and extrusion lamination, heat and pressure are inherent in the process.

When an extrusion resin is used either for coating or extrusion lamination, the introduction of ozone into the extrusion nip offers some very important benefits.

The adhesion of the melted resin to the substrate is dependent on the oxidation of the resin, just as we have seen in corona discharge treatment.

In order to get a high degree of oxidation a high extrusion die temperature is used. Good oxidation takes place at around 610°F (321°C).

With the use of ozone, the same amount of oxidation will take place at a much lower temperature, around 450°F (232°C), or at a higher machine speed.

Ozone can be directed to the side of the melted resin that is to adhere to the substrate, leaving the other side virtually free of oxidation for easier heat sealing and lower odor.

Resins such as EVA which must be extruded at low temperature, respond well to ozone exposure.

The equipment consists of an ozone generator which is like a corona unit, ducts to carry the ozone to the extrusion nip and an exhaust system, if needed.

The use of ozone by people with extrusion equipment is growing. Water based systems, applied to the substrate, bond well to these highly oxidized melts.

Because they are so thin and clear after being applied to a film and dried, water based systems are used as tie coats under inks. Good ink adhesion to film is always desirable. It becomes necessary when the ink covers the seal areas.

Aluminum foil has an entirely different surface chemistry than packaging films so that water based adhesives and primers depend on very different bonding elements. We use mineral or organic acid groups to attack the aluminum surface and a set of organic functional groups to bond to the film.

We have developed one system for aluminum to polyethylene which deserves special mention.

We have an acid end which combines with aluminum to form an insoluble salt, and an organic end which bonds firmly to the polyethylene. We incorporate a coupler which insolublizes the body of the adhesive.

When the system is cured, the bond will withstand water; solvents such as MEK, toluene, acetone; salts;

acid and alkali; oil, grease, even some essential oils and flavorings. The structure is useful for packages which are to hold food, chemicals, packaged cements and adhesives, and cosmetics, even oily nail polish remover and toothpaste.

One of our paper coatings is used for ethylene oxide sterilization pouches. Requirements here are high.

The coating must adhere to film yet give a fibre free, peelable seal. It must be porous to ethylene oxide, it must be made of non-toxic chemicals and it cannot cling to the contents of the pouch.

This coating, again, conserves petrochemicals as it is used at a rate of but one half-dry pound per ream (0.8 grams dry per square meter).

We have examined film-to-film bonding, the adhesion of aluminum foil and a paper coating. These are but a few of the many uses for water based materials in flexible packaging. When used properly, they can be incorporated into structures for a number of end uses since they offer clarity, high peel strength, and exceptional heat seal bonds.

Packages produced from stocks bonded with water based materials are resistant to moisture, water, hot water, freezing, and heat. The heat of thermoforming is usually good for the bond. These packages also resist oils, acids, spices and even solvents.

Packages made with water based materials may be used for meat, cheese, moist and dry powders, toys, surgical instruments and dressings, condiments, drugs, cosmetics, chemicals, and on and on.

Aqueous systems go a long way toward solving many of the problems we face today. They do not pollute the air, they can be transported with no special labels, they are not harmed by freezing in transit, they can be stored indefinitely, they give off no toxic fumes, and no special handling precautions are necessary. They are one part systems with unlimited pot life. There is no solvent trapped between the webs, most cure within about five minutes in the rewind, clean-up is with water, and they don't present a disposal problem. The cost on a ream basis is very small. They conserve petrochemicals and they don't waste energy.