ARIZONA CHEMICAL: CONVERTING PAPERMAKING AND CITRUS BYPRODUCTS TO PERFORMANCE CHEMICALS AND MATERIALS

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Arizona Chemical, a leader in the pine chemicals industry, is a global manufacturer of specialty and commodity chemicals that are used in twenty-eight (28) market segments, around the world. Arizona Chemical's mission is to process by-products from the kraft pulping and citrus juice industries, into value-added products, primarily for the adhesives, inks and polymer industries. Our technology is based largely on renewable resources. However, we use petroleum-based feedstocks as well, because it enables us to use our renewable feedstocks in a manner that provides unique functionality to our customers.

Arizona Chemical is successful because it has developed solid technology platforms and uses sound business fundamentals to manufacture products, which give performance and value to our customers. We are not successful only because we use renewable resources. Arizona Chemical differentiates itself from other successful chemical companies with its feedstocks and technology.

About Arizona Chemical

Arizona Chemical is headquartered in Jacksonville Fla. and employs about 2000 people worldwide. There are 15 manufacturing facilities worldwide and three technology centers, in Savannah Georgia, Panama City Florida and Almere the Netherlands. Our manufacturing facilities are shown on slide 6.

History of Arizona Chemical

Arizona Chemical began in 1930 as a joint venture between International Paper and American Cyanamid to mine salt cake in Arizona (hence our name). In 1936, it started up a plant in Panama City, Florida (next to an International Paper mill) to distill crude sulfate turpentine into its major components, alpha-pinene and beta-pinene. In those days, one technical achievement was sufficient to start up a new manufacturing facility. In 1949, Arizona Chemical started the world's first continuous tall oil distillation plant, also in Panama City. This unit produced tall oil rosin and fatty acids simultaneously. The distillation technology was an adaptation of techniques developed to fractionate crude petroleum streams. By this time, Arizona Chemical ceased its mining operations in Arizona.

The second phase of our company began in 1952, when we started upgrading turpentine streams. Pine oil was commercialized in 1956. In addition to developing the initial hydration reaction technology, we developed technology to desulfurize (sweeten) the alpha-pinene to produce pine oil with a good odor. This development was followed by many new technical efforts to upgrade both alpha-and beta-pinene and also the rosin and fatty acid streams from the Panama City refinery. A new terpene resin plant was built in 1971 in Panama City. Rosin esters were introduced in the 70's also. By the late 70s, Arizona Chemical was the leader in using pine chemicals in resins for adhesives and the rubber industry and was the largest producer of tall oil fatty acids for the coatings and surfactants industries.

Arizona Chemical entered its third phase of growth in 1985, when International Paper acquired complete ownership of the company from American Cyanamid. Recognizing that the pine chemicals industry had many competitors and served a broad range of markets and that the changing business climate was bringing new challenges, the company started a number of strategic acquisitions. Sylvachem was the first acquisition, followed by Sweden's Bergvik Kemi, Reichhold's Newport Division, the Peterson tall oil refinery in Norway, the DSM ink resin business and the Forchem Oy tall oil and turpentine business in Finland. Each of these acquisitions filled a critical requirement in Arizona Chemical's strategy to be a global chemical company. In 1999, the chemical divisions of International Paper and Union Camp were merged.

Arizona's history, especially in the last 10-15 years is fundamentally the same as other successful chemical businesses. There was a modest beginning, driven by technological achievements, followed by a marketing effort to capitalize on those achievements. Efforts then focused on developing the technology platforms to drive the business.

Pine Chemicals Value Chain

The pine chemicals value chain illustrates the conversion of papermaking by-products to chemicals and materials for industrial and consumer use. The Kraft pulping of pine trees produces roughly 450 lbs. of chemical by-products and 5 tons of cellulose pulp from 10 tons of wood chips. As you can see, the papermaking business has always been a rich source of chemicals. In turn, these chemical by-products are distilled and treated to afford high purity intermediates that are upgraded to yield functional chemicals, polymers and resins. Our customers use our products to manufacture a wide range of consumer and industrial products.

Kraft pulping produces two types of chemical by-products, crude sulfate turpentine (called CST in the industry) and crude tall oil (called CTO in the industry).

CST is a complex mixture, comprised mainly of ten (10) carbon terpenes, with lesser amounts of aromatics and fifteen (15) carbon terpenes. Moreover, the gross composition varies depending on the geography of the tree. In Southern CST, which is used by Arizona's Panama City refinery, the major terpenes are alpha-pinene and beta-pinene that are isolated in very high purity, enabling them to be used as feedstocks for selective chemical reactions. (One of the key requirements for using a renewable resource is the development of technology to obtain very pure chemicals. In some cases, it is possible to perform chemical reactions on mixtures in a selective manner, and in some cases even desirable to do so for economic reasons, but these are exceptions). Both pinenes are converted to resins with controlled molecular architecture that are used for adhesives, chewing gums, polymer additives and into pine oil. Some beta-pinene is used by other producers, that convert it to flavor and fragrance compounds and vitamin intermediates.

One of the minor components in CST is converted to anethole, the main component of anise (licorice) flavors.

CTO is also a complex mixture, comprised of rosin acids, fatty acids and many non-acidic compounds (called neutrals in the industry). With a series of distillations, CTO is separated into these components. Rosin itself is a complex mixture of unsaturated tricyclic carboxylic acids, with similar structures. Because both the acid group and double bonds are so reactive and structures of the components are similar, rosin is converted to a broad range of resins, which are used in many adhesive and ink applications and chewing gums.

Rosin is also reacted to form an emulsifier used in latex rubber manufacturing for tires.

The fatty acids are also a complex mixture, comprised mainly of saturated, unsaturated, diunsaturated 16 and 18 carbon compounds. Because of the complexity of the fatty acids, obtained by distillation, the useful chemistry that is possible is limited to simple esterifications and clay catalyzed dimerizations, both of which Arizona Chemical practices. The esters are used mostly as "green" solvents for ink making and for lubrication. For the most part however, the fatty acids are sold to others that have specialized technology for surfactant manufacture and alkyd resin production for coatings.

The neutrals in tall oil are sold mostly as pitch for fuels and rubber compounding (tires). However, pitch is also a source of sterols, which can be converted to more complex stanols.

<u>A New Resource is Introduced….From the Orange Juice Industry</u>

In the 1960s, the Heyden Newport Company, the predecessor to Reichhold's Newport Division, discovered the means to polymerize racemic limonene, obtained by the pyrolysis of alpha-pinene, to afford resins which performed well in hot melt adhesive systems. Limonene resins have different properties from beta-pinene and alpha-pinene resins. However, this limonene was relatively expensive to make. Moreover, most adhesives were still based on solvent processes, which used beta-pinene resins (and to some degree the very early petroleum hydrocarbon resins and other crude resins). Consequently this technology did not take off.

This changed with the discovery that the orange juice industry produced millions of pounds of crude limonene as a by-product, most of which was burned. It did not take long to learn how to upgrade this crude limonene to make it suitable for polymerizations. This turned out to be a very economical source of limonene. In turn, technical advances in the adhesives industry and increased environmental regulations for solvent emissions resulted in the development of many new hot melt adhesives. Additional advances by Arizona Chemical in the 80s resulted in enormous growth for limonene resins. The lesson learned from this experience is that being truly committed to renewable feedstocks usually requires constant research and development activity to capitalize on opportunities when they arise and to even create opportunities. By the way, the advent of limonene as a resin monomer did not decrease the utilization of beta-pinene. This terpene has a unique chemistry that has resulted in many other commercial products based on it for example, geraniol (fragrances), citral (flavors, fragrances, vitamin intermediate) and l-menthol (medicinals, toothpastes).

<u>Arizona Chemical's Manufacturing Processes</u>

Arizona's manufacturing expertise is as follows: hydration, isomerization, disproportionation, dimerization, polymerization, aromatic alkylation, metalation, polyamidifcation, esterification, tall oil acidulation, fractional distillation, desulfurization, oxidation, rotoforming, flaking, dispersions, specialized packaging Our scientists and engineers developed almost all these technologies.

<u>Arizona's Markets</u>

Arizona Chemical sells into 28 markets. The markets in bold type, are the ones in which we have technical expertise. As examples, we run emulsion polymerizations in the laboratory to test our rosin emulsifiers just like they are done in the industry. We make adhesives with our resins and dispersions then test them exactly as done by our adhesives customers. For the last decade, Arizona has offered its expertise in adhesive science and rheology to its customers as a service. Our technical expertise in inks/graphic arts is also world class.

<u>Arizona Chemical's Raw Materials</u>

Being committed to renewable resources does not mean never using any petroleum based feedstocks. One of the keys to our success has been our ability to invent and develop new chemistry with terpenes and tall oil fractions by utilization of petroleum based raw materials. In this manner, for example rosin is converted to rosin esters (with glycerin and pentaerythritol), terpenes are reacted with phenol to afford valuable items of commerce for many markets and fatty acids are converted into everything from adhesives to inks to components for television sets.

EXAMPLES OF ARIZONA CHEMICALS SUCCESS IN UTILIZING WOOD BASED RAW MATERIALS

Now that I have described Arizona Chemical's business as a renewable resource based chemical company, I would like to discuss some specific examples of our success in commercializing materials based on wood derived chemicals. These accomplishments were critical in our growth and allowed us to use renewable resources on a large scale.

<u>Alpha-Pinene Resins</u>

Alpha-pinene is the most abundant terpene in the turpentine produced from the Kraft pulping process in the Southern US. However, it is the most difficult to polymerize to useful resins. Using the common catalysts, this terpene reacts to give low molecular weight resins that had little use in the 70s. However, Arizona scientists, working together with a world class adhesives manufacturer, discovered that alpha-pinene resins could be optimized to make quality adhesive tapes. The result was the commercialization of the Zonarez® A-25 resin.

<u>New Terpene Phenol Resin Plant</u>

In the early 1980s, Reichhold's Newport Division, now part of Arizona Chemical, lost a huge share of its terpene phenol resin business. A new management however realized the potential of this business and committed to building a new plant. New technology was developed that leapfrogged the competition and opened up new adhesive markets. The plant is now in its 14^{th} year in Pensacola. This technology is now the largest consumer of alpha-pinene for Arizona Chemical.

<u>Terpene Phenol Resins for Automotive Assembly</u>

Terpene phenol resins were developed originally for the paint and varnish industry. With major improvements in technology, several adhesives markets were developed as well. In the 1990s, Arizona scientists, in collaboration with a polymer manufacturer developed an optimum terpene phenol resins based on alpha-pinene for automotive assembly and using new technology produced it in the Pensacola plant. This was Arizona Chemical's first big entry into the polymer additives market.

<u>AQUATAC® Dispersions</u>

In the 1970s, an Arizona Chemical vice president (VP) had the vision that one day, waterborne adhesives would become important items of commerce. At the time there was no hard marketing data to support this belief. Moreover, other companies that had this vision and *were* in the business of making waterborne tackifier resins had little to show for their efforts. But the VP persisted. To explore his idea, the VP asked several dispersion manufacturers to try to disperse two commercial rosin esters. The initial prototypes were failures and the idea failed to materialize. In the 80s, new managers became intrigued with this idea. By this time, the future of waterborne technology was much clearer. Because of the VP's earlier efforts, it was relatively easy to restart this program. At the time, Arizona Chemical had no real in-house technical expertise in dispersions. Because of this and the perceived difficulties in developing the expertise, a decision was made to license another company's dispersion technology.

However, when this company's technology turned out to be unsatisfactory, Arizona changed course, deciding to try to develop its own technology from scratch without the benefit of any outside consultants. This was an enormous undertaking. Although the decision was contrary to prevailing business theory, Arizona Chemical did develop its own technology and started up a new dispersion plant in 1992.

<u>Dispersions for Environmentally Friendly Adhesives</u>

Since the start up of the new dispersion plant, Arizona Chemical has been working to grow the business. One of the results of this effort is a new rosin ester dispersion that is now being used to make the adhesive for environmentally friendly postage stamps. This is part of a large effort by the US Postal Service to integrate environmentally sound products into its operations. It involves a world class adhesives manufacturer and two other divisions of International Paper.

<u>Clear Candles</u>

In 1996, Union Camp scientists were working to develop fatty acid based gellants for personal care products when they discovered a new class of resin that would gel a number of organic liquids. Eventually they developed a gelling resin that could be used to make clear candles. These new candles were introduced successfully to the marketplace in 1999.

SOME THOUGHTS ON ADVANCING THE UTILIZATION OF RENEWABLE RESOURCES

The purpose of the Cellulose Conference is to advance the utilization of materials derived from wood and from other renewable resources. Towards that end, I have provided a real world story of how one chemical company did precisely that. The lesson learned from Arizona Chemical's history is that success will come only from developing world class technology, sound economics and good business practices. The reality of our world is that the "feel good" aura of the term "renewable resources" does not influence customers. The performance and value of the products made available to customers influences them. A proven record of technical creativity and innovation also influences them.

A chemical business based on renewable resources is not immune from competition. Most of Arizona Chemical's products in fact have competition from products made from petroleum feedstocks. Many of Arizona's competitors use good business practices and are technically creative and innovative as well.

What should be done to increase the utilization of renewable resources? As a start, more effort must be devoted to fundamental research and development by the chemical industry. The Dow-Cargill joint venture to make polylactide resins from an agricultural feedstock is a good example of what is needed. But it is rare today. Since the 50s and 60s, the chemical industry, with the exception of the pharmaceutical industry, has been scaling back its research and development efforts. Many companies have established core technical competencies and no longer feel justified in spending money on R&D in new areas. (Adding to this situation is that much of the fundamental R&D that is occurring is in the petrochemical area, an example being single site catalysis). Unfortunately, reversing this trend will not be easy because we have cultivated several generations of managers that for the most part do not (or can not) appreciate the value of the technology leadership that comes from fundamental R&D.

SUMMATION-ACKOWLEDGEMENTS

In closing, I would like thank the organizers of this symposium for the opportunity to represent International Paper and Arizona Chemical in the effort to advance the utilization of renewable resources and to share some of my own views on how to succeed. I would also like to thank Arizona Chemical for this opportunity as well.