Similar experiments have to be designed for other potential problems.

In summary, various governmental regulations from a number of agencies mandate the safety of household products from manufacture through use, or possible misuse, to eventual disposal. This paper has shown how we meet this need and how we often go much further to satisfy our desires to market truly safe products.

Surfactant Raw Material Outlook for the Eighties

J.S. BINDO and **G.D. SMITH**, Conoco Chemicals, Co. Houston, TX

ABSTRACT

Over the next decade, the surfactant industry should be able to secure an adequate supply of the raw materials necessary to provide its need for surfactant intermediates. Since the U.S. will continue to rely on foreign imports for marginal crude supplies, periodic disruptions in raw material supply are likely to occur. World crude prices are expected to rise more rapidly than the general U.S. inflation rate and surfactant feedstocks are expected to track world crude prices as a whole. Over the next few years, ethylene prices should increase faster than other surfactant feedstocks. This should occur as a result of natural gas price decontrol and improved ethylene profit margins. Otherwise, in the long term, the major driving force for all three synthetic feedstocks should be the price of world crude. Of course, short term perturbations, e.g., plant shutdowns and over-supply situations, may cause one feedstock or the other to increase at somewhat higher or somewhat lower rates for short periods of time. Natural oils may represent an interesting alternative to crude-oil-based alcohols. Longer term, average prices for natural oils should increase at lower rates than world crude oil. However, natural oil prices have historically been much more cyclic than crude prices and "natural" alcohol producers run the risk of being noncompetitive during tight supply/demand periods.

INTRODUCTION

In the midst of the current recession with spot prices, even of refined products, below contract prices and falling, petrochemical producers are now more interested in maintaining volume and margins than in future feedstock supply security. Still, having experienced the sharp price increases and supply shortages of 1974 and 1979, a lingering concern over future feedstock availability and pricing remains. In general, the surfactant industry has done well in its battle with the fuels industry for its needed feedstocks. The surfactant industry's success, like most petrochemicals, can be attributed to its value added, labor and GNP advantages vis-a-vis the fuels markets (1,2). These advantages will continue and, therefore, the detergent industry should continue to acquire the feedstocks necessary for growth. However, prices, which are driven by world crude prices, should rise significantly higher in the next few years.

SURFACTANT INTERMEDIATE RAW MATERIALS

Basic surfactant intermediates are produced from petroleum (or natural gas liquids) products and natural oils. Detergent intermediates produced from petroleum-derived ethylene, benzene and normal-paraffins are usually referred to as "synthetic"; alcohols produced from agriculturally derived fatty acids are referred to as "natural."

SYNTHETIC SURFACTANT FEEDSTOCKS

"Synthetic" feedstocks are produced from refined petroleum products or natural gas liquids—ethane, propane or butane. Crude oil is processed in refineries into various "virgin" products, e.g., naphtha, kerosene and various gas oil or distillate streams (3). Natural gas liquids (NGL) are extracted from "wet" natural gas streams (either "associated" or "unassociated" with crude oil production). NGL, naphtha and gas oil are common feedstocks for ethylene "steam crackers" (3-7). Naphtha also can be "reformed" into highly aromatic gasoline range products that yield significant quantities of benzene (3,9,10). Normal paraffins are extracted from refinery kerosene streams (3).

NATURAL SURFACTANT FEEDSTOCKS

Naturally derived, long chain fatty acids also are used as raw materials for the surfactant industry. The preferred fatty acids are lauric types derived primarily from coconut oil, and minor amounts from palm kernel oil. These natural oils can be hydrolyzed or reacted with methanol to produce glycerine and either methyl esters or fatty acids.

U.S. ENERGY DEMAND

Natural oils now represent less than 5% of the total raw material requirement (including ethylene oxide) for the surfactant industry. Therefore, at least in the foreseeable future, surfactant feedstock availability and price will be influenced primarily by the three petroleum derived feedstocks—ethylene, benzene and *n*-paraffin.

These products share two significant characteristics that influence their availability and price: (a) each is petroleum-derived; (b) each is produced "on-purpose." "On-purpose" means that each is the primary product from a particular production facility, as opposed to being a "coproduct" or "byproduct." For this reason, the price, over the long term, is going to be cost-related and the availability (long term) will depend on the relative margin above cost, i.e., demand drives price and, hence, supply.

Since all are petroleum-based, the U.S. and world crude oil situation is extremely important to the surfactant industry. Will the detergent industry continue to import a majority of its crude oil? Will OPEC continue to control the price? To answer these questions one must look at the total U.S. energy picture—today and over the next decade or so. In 1980, the U.S. can be expected to consume about 76 quadtrillion BTUs (Quads) of energy (only 2% greater than the 1973 pre-embargo peak). Over the next 10 years, total energy demand is projected to increase less than 1.5%/yr. This projected growth rate is significantly lower than in the 1960s (4%) and is the result of increased conservation brought about by higher relative energy costs and lower overall economic growth.

Coal is expected to provide a greater proportion of the U.S. Energy needs. Coal's share of the total energy supply

should increase from 20% in 1980 to about 26% by 1990. By 1990, nuclear energy should provide almost 9% of the domestic energy requirement.

Total U.S. natural gas supplies, including imports, are expected to decline by about 12% during the next 10 years. Increased imports of seaborne liquified natural gas and Mexican gas plus the expected completion of the Alaska/Canada natural gas pipeline in the mid-1980s will not be sufficient to offset production declines in the lower 48 states. Synthetics are expected to contribute less than 2% to U.S. natural gas supplies by 1990. What does this mean for crude oil?

U.S. OIL DEMAND

While petroleum will provide a decreasing share of the U.S. energy requirement (on a percentage basis) over the next 10 years, it will remain the single, largest source of energy for the U.S. Although future U.S. crude oil demand is expected to remain near 1980 levels, the forecasted 1990 demand level is about 1 million barrels per day below peak demand levels reached in 1978. This almost stagnant growth is a far cry from the 4-5%/yr growth rate common before the 1974 oil embargo. In addition to slower economic growth, price-induced conservation and substitution of alternative fuels, plus government-mandated conservation measures will contribute to lower demand.

Lower crude oil demand is most evident in the gasoline market. Gasoline demand peaked in 1978. Government mandated fleet fuel efficiency standards and higher prices will continue the trend toward smaller, more fuel-efficient automobiles. Greater use of diesel powered automobiles also will reduce gasoline demand.

Demand for kerosene range jet fuels should grow at about 2%/yr. Growth in air travel typically grows along with the economy but improved airline efficiency should help moderate jet fuel demand.

Distillate demand should grow at less than 2%/yr. Residential and commercial consumption of home heating oil should stagnate, since natural gas is likely to be used in most new home construction. Industrial consumption of distillate also should drop. Distillate demand growth will come from increased use in the transportation sector (trucking and new diesel cars).

Substitution of coal and nuclear power should cause residual fuel oil demand to decline sharply. Bottom of the barrel conversion projects will be required to keep refinery units in balance.

U.S. OIL SUPPLY/DEMAND

With the progress being made toward reduced crude oil demand, will dependence on foreign oil imports continue? The prospects for greater crude oil exploration have improved, but domestic crude oil production is expected to continue to decline, albeit at lower rates than experienced in recent years. Supply from the North Slope of Alaska is assumed to hold at about the current level of 1.5 million barrels per day and synthetics are not expected to contribute more than 400 thousand barrels per day to the total U.S. oil supply in 1990.

This analysis implies that the U.S. will continue to import petroleum—less than the 8.5 million barrels-per-day target President Carter agreed to at the Tokyo Summit last summer and less than the demand peak required in 1977 of 8.5 million barrels per day—but still, imports are expected to represent over 40% of our total crude oil requirements over the next decade.

NON-COMMUNIST WORLD CRUDE OIL SUPPLY

Does this mean the U.S. will continue to rely on OPEC for its marginal crude oil supply? Absolutely! An analysis indicates that even with an optimistic outlook for production in non-OPEC countries, the non-communist world must rely on OPEC for about half of its crude oil needs over the next decade. In order to balance crude oil supply and demand, in 1990 OPEC will need to produce 25 million barrels of oil per day, somewhat less than expected 1980 rates of 27 million barrels per day. The 1990 figure includes about 1.3 million barrels per day for net communist world demand. Mexican crude oil production is expected to double over the next decade.

Although non-Saudi-Arabian OPEC production is expected to be somewhat below expected production capacity (about 20 million bbl/day) the forecast is consistent with the oil conservation philosophy that has evolved in most economically self-sufficient OPEC countries.

This analysis implies that Saudi Arabia should regain increased leverage over OPEC oil policies. This should help restore some stability to world crude prices. Even though the world crude oil situation "on paper" appears encouraging over the next decade, the events of the last two years should serve as a warning that future supply disruptions are still possible, and indeed, even probable.

U.S. ETHYLENE FEEDSTOCK TRENDS

With the exception of short-term, politically inspired supply disruptions, sufficient crude oil should exist to supply the crude oil requirements of the U.S. fuel and petrochemical industry. But it is believed that OPEC will maintain the purchasing power of its major resource by raising world crude prices somewhat faster than the general U.S. GNP price deflator. How will this affect the basic surfactant feedstocks, ethylene, benzene and *n*-paraffin?

First consider ethylene. Until recently, the U.S. ethylene industry had been based primarily on natural gas liquids (5), first propane and then ethane (Fig. 1).

In 1976, about 80% of the U.S. ethylene production was based on natural gas liquids. By 1980, this percentage should drop to almost 60%. A continued trend toward a high use of refinery liquids is dictated, at least through 1985 (4,6), by the fact that, with the exception of the new Phillip's one billion 1b/yr ethylene plant at Sweeny, Texas, every new ethylene plant started-up recently and through 1984 will be based on cracking of refinery liquids. Beyond 1984, such considerations as (a) feedstock security and flexibility, (b) continued demand for coproducts—propyl-

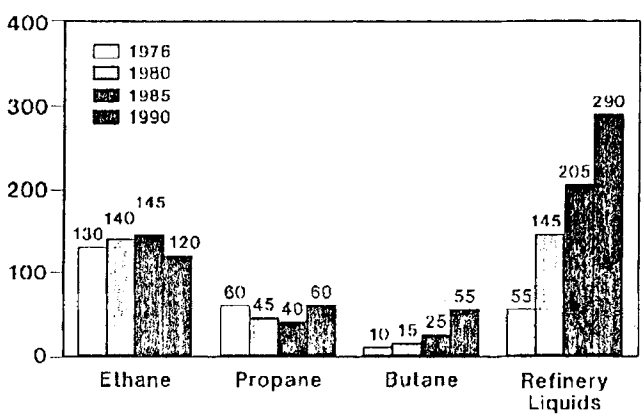

FIG. 1. U.S. ethylene feedstock trends (millions of barrels/yr).

ene, benzene and butadiene—produced in heavy liquid crackers, (c) decreasing domestic natural gas supplies, and (d) decontrol of U.S. natural gas prices, should dictate the continued trend toward heavy liquids (4,5,7,8). While the increase in demand for refined products is significant, the demand by the petrochemical industry for refined products should remain manageable. By 1990, the U.S. ethylene industry is expected to consume less than 8% of the total domestic crude oil requirements (this total includes NGL feeds and excludes any credit for fuel streams returned as refined products). This represents less than 3% of the total energy requirements for the U.S.

U.S. ETHYLENE SUPPLY/DEMAND FORECAST

Another factor affecting ethylene availability and price is the current over-supply of ethylene (Fig. 2). By the end of 1980, U.S. ethylene capacity will exceed demand by about 10 billion lb/yr. As a result, heavy liquids cracking is yielding very little or no profits (4). However, even with demand growing at only 4%/yr, the excess capacity will be worked off by the mid 1980s. Furthermore, derivative capacity announcements indicate that ethylene consumption capacity will exceed ethylene derivative capacity by 1983 (11). Since ethylene supplies must be lined up a year or so prior to start-up, it is likely that security of supply considerations will begin to allow ethylene plant margins to improve significantly in the next few years.

The demand for ethylene in the production of α-olefins and detergent alcohols accounts for less than 4% of the total U.S. ethylene demand. The demand for ethylene oxide used in the production of nonionic surfactants only brings the total up to about 6%. The demand for ethylene in the production of surfactant intermediates therefore does not have a significant effect on the supply/demand balance for ethylene.

PRICE FACTORS—ETHYLENE

What do these analyses imply about ethylene prices—that ethylene prices will be affected by (a) crude oil prices, which should increase faster than the general inflation rate, (b) refinery profitability which sets the price of refined products, and (c) coproduct prices, such as propylene, benzene and butadiene. In addition, the near-term natural gas price controls will supply the incentive to extract the maximal amount of ethane from natural gas for steam cracking. Once natural gas prices are decontrolled, the incentive will be reduced drastically and result in cost-driven ethane prices versus the ethylene price-driven ethane prices which exist today. Ethylene profits, which reflect to a large extent return on capital, are surely due for an increase.

Over the long term, ethylene prices should be set by crude oil prices, coproduct credits and capital costs, but in the next several years decontrol of natural gas prices and its effect on NGL prices plus a return of ethylene profits will play an important role in increasing ethylene prices.

U.S. KEROSENE SUPPLY/DEMAND

Now examine normal-paraffin, which is produced from refinery kerosene. The *n*-paraffin merchant market in the U.S. is dominated by one U.S. supplier and, therefore, discussions of *n*-paraffin price and availability may not be very helpful. Instead, consider the price and availability of the feedstock for normal-paraffin, kerosene. With the exception of a small amount of imports, domestic kerosene is derived entirely from virgin crude. Over 80% of kerosene

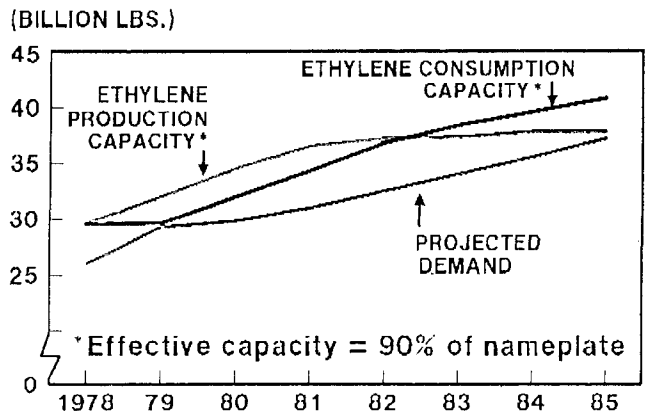

FIG. 2. U.S. ethylene supply/demand forecast.

consumed domestically is used as jet fuel. The remainder is used in residential and industrial fuel applications. Jet fuel demand will increase about 2%/yr and is expected to more than offset a projected decline in demand in the other sectors. Normal-paraffin production consumes less than 1% of the total kerosene produced domestically and, therefore, represents very little drain on total kerosene supply.

PRICE FACTORS—NORMAL-PARAFFIN

What does the supply/demand balance imply for kerosene prices? First, normal-paraffin prices will be affected by crude oil values through the price of refined fuels. Since kerosene must be separated from distillate fuels, it typically sells for a premium over home heating oil. Furthermore, since kerosene demand is expected to grow faster than crude oil demand overall, the premium paid for kerosene should increase somewhat long term. Although the U.S. merchant market is dominated by one producer, it is clearly affected by the world paraffin supply situation, where Liquichimica's enormous capacity has restrained capacity expansion over the last few years. Over the long term, however, crude oil values will be the predominant factor affecting normal-paraffin prices.

U.S. BENZENE SUPPLY/DEMAND

Benzene is produced from a variety of sources at widely differing costs. The primary source historically and today of benzene has been via extraction from refinery reformate, a high octane gasoline stream produced by the catalytic reforming of light naphtha streams. Extraction from steam cracker pyrolysis gasoline streams is the third largest source. Benzene produced from pyrolysis gasoline should grow rapidly as new heavy liquid crackers come on stream. The second largest source of benzene is from the "on-purpose" hydrodealkylation of toluene (and xylenes). This source represents the swing supply and typically sets the price of benzene. Minor quantities of benzene also are extracted from coal tar.

Aromatics, in particular toluene, also are important sources of high octane for unleaded gasoline (9,10,12-14). For this reason, the price and availability of toluene and, hence, benzene are highly influenced by gasoline demand and quality.

On the demand side, the major uses of benzene are styrene (primarily for plastic applications), phenol (resins and plastics), and cyclohexane (nylon). Detergent alkylate demand for benzene only represents about 2% of the total demand. Clearly, increases in detergent alkylate

demand should not cause any significant change in the demand or price of benzene.

PRICE FACTORS—BENZENE

As the allowable lead level in gasoline decreases, the demand for high octane blending components in gasoline on a per-gallon basis will increase (7-9). However, the expected decrease in overall gasoline demand should partially or totally offset the higher gasoline octane requirement over the long term. In the short term, however, the price and availability of benzene is complicated by government regulations. The government has mandated that the total lead level used in gasoline blending be reduced to levels below that required by normal conversion to unleaded gasoline. The mandated lead level of 0.5 g/gal for the total pool and the implementation schedule were relaxed and delayed several times in 1979 and 1980 with profound effect on toluene and, hence, benzene demand and price (9,13,14). In addition, government gasoline price controls have, at times, resulted in upward pressures on benzene prices (13).

Since the last increment of benzene production is "on-purpose," petrochemical demand also can place strong pressures on benzene price. Modest swings in chemical demand for benzene can have a dramatic effect on the use of the HDA capacity serving the merchant market.

In the short term, any of these factors could cause the price of benzene to move up or down quickly, but over the long term, the major influence on benzene prices will be crude oil prices.

U.S. CONSUMPTION OF FATS AND OILS

The U.S. currently produces about one third of the total world's fats and oils, and exports about half of that production. The U.S. consumes about 20 billion pounds/yr of fats and oils. Fatty acid production only accounts for 10% of the total with the bulk, about 75%, being consumed in the various food markets. Coconut oil, the primary source of surfactant range fatty acids, is totally imported. Over 50% of the imported coconut oil is consumed in the food market and fatty acid production accounts for about half of the remainder. The food markets dominate the demand for all fats and oils.

PRICE FACTORS—NATURAL OILS

In many applications (e.g., food) one natural oil can be substituted for another which typically means that world fats and oil prices rise and fall together, although not always not be the same magnitude. Therefore, the price of coconut oil is very dependent on total oilseed productivity, in particular soybeans. Likewise, natural phenomena that could result in massive crop failures have a significant impact on world fats and oils supply. Like most other world food crops, coconut productivity should continue to improve. Therefore, on a trend line basis, coconut oil prices can be expected to grow somewhat less rapidly than U.S. inflation rates but as has been the case in the past, prices will be very cyclic.

REFERENCES

1. Petrochemicals: Their Economic Significance in the Domestic Economy, U.S. Department of Commerce, Washington, DC, July 18, 1979.
2. The Petrochemical Industry and the U.S. Economy, Report to the Petrochemical Energy Group by Arthur D. Little, Inc., December 1978.
3. World Conference on Soap and Detergents, "Petrochemicals—Viable Raw Materials for Tomorrow's Soap and Detergent Industry? E.D. Haupt and P.B. Schwin, Montreux, Switzerland, October 1977.
4. 88th National AIChE Meeting, "Olefin Feedstocks," R.A. Klein, Philadelphia, PA, June 1980.
5. National Meeting of the Chemical Industry, "Petroleum and Its Impact on the Petrochemical Industry," J.W. Sauer, Mexico City, October 1979.
6. Chemical Week, "How Exxon Chemical Prepares for the '90s," E.C. Holmer, July 30, 1980, pp. 38-41.
7. Chemical Week, "No Dearth of Favored Feedstocks," July 16, 1980, pp. 41-42.
8. Chemical Market Research Association Meeting, "The Effect of Changing Energy Values on the Ethylene Business," R.A. Klein, New Orleans, LA, November 29, 1978.
9. Southwest Chemical Association Monthly Meeting, "Gasoline versus Petrochemicals . . . Feast or Famine," J.D. Dewitt, June 12, 1980.
10. 86th National AIChE Meeting, "Impact of Manufacturing and Refining Issues on Aromatic Supply," W.J. Magers, Houston, TX, April 3, 1979.
11. Industrial Safety Equipment Association Meeting, "Outlook for Energy and Petrochemical Feedstocks," R.W. Gerwig, November 15, 1979.
12. Chemical Market Research Association Meeting, "BTX: Derivatives Future Shock or Future Surplus," J.D. Dewitt, New York, NY, May 10, 1979.
13. Chemical Market Research Assocation Meeting, "Toluene—Destined for the Chemical Industry or for Gasoline," W.C. Bowman and T.A. Acosta, New Orleans, LA, November 29, 1978.
14. 86th National AIChe Meeting, "Aromatics Forecast, 1978-81," P.E. Baggett, Houston, TX, April 3, 1979.