Letters

Gasoline Substitutes

During a recent discussion of shortages, a colleague mentioned ethyl alcohol as a likely substitute for gasoline (*1*). Following up on the idea, I found this interesting statement in an old organic chemistry textbook (*2*, p. 18).

> If industrial ethyl alcohol becomes a substance which is used by the community in very large quantities (which might occur if the gasoline supply were exhausted), the production of alcohol from cheap forms of starch would become an enormous industry of the greatest importance.

Let us go a step beyond starch and imagine that some enterprising chemist discovers a cheap, rapid method of hydrolyzing cellulose into its basic component, glucose. Weed-pulling and leaf-raking might then become profitable, and we could soon be fermenting enough alcohol to float the earth. Burning alcohol offers the additional advantage of reducing the production-consumption cycle by several million years, when compared to that of fossil fuels.

The antibiotic industry is being mentioned as a potential victim of an impending petroleum-related shortage of acetone. In the 1930's acetone was obtained by fermentation (*2*, p. 129). Conant does not identify the bacterium involved, but *Clostridium acetobutylicum* and related species are known to produce up to 30 percent of mixed solvents, including butanol and acetone (*3*, p. 24).

Microorganisms have still more to offer. The members of the genus *Methanobacterium*, of course, produce methane, a constituent of natural gas, under the anaerobic conditions found in stagnant water, mud, and sewage (*4*). *Claviceps purpurea* generates *n*-propylamine (*3*, p. 294) and *n*-hexylamine (*3*, p. 294), which, deaminated, would yield propane and hexane, respectively. The ubiquitous *Pseudomonas aeruginosa* is also described as a producer of 2-*n*-heptyl-4-oxyquinoline (*3*, p. 494). The 7-carbon side chain protrudes like a turkey neck inviting the chemist's cleaver.

While some of these chemical items may not now be retrievable in commercial quantities, it should be recalled that, in the early 1940's, antibiotic manufacturers were able to transform *Penicillium* from a miserly into a comparatively generous donor of penicillin.

The United States need not be hamstrung by the Arab oil embargo (or the oil industry, depending on which news analyst one believes in). Bacteria, molds, and yeasts are ready to go to work for us, and they have the indisputable advantage of being politically neutral. Granted, the effort will involve the expenditure of large sums of money. New, modified, or resurrected chemical processes, and certainly new or modified engines, will be required. Our industrial giants, however, are presently enjoying record profits, and what are profits for but to help finance inevitable changes and necessary developmental costs?

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References

1. For an excellent article on methanol as a fuel, see T. B. Reed and R. M. Lerner, *Science* **182**, 1299 (1973).
2. J. B. Conant, *The Chemistry of Organic Compounds* (Macmillan, New York, 1934).
3. M. W. Miller, *The Pfizer Handbook of Microbial Metabolites* (McGraw-Hill, New York, 1961).
4. R. S. Breed *et al., Bergey's Manual of Determinative Bacteriology* (Williams & Wilkins, Baltimore, Md., 1957), p. 250.

As a partial solution to the gasoline shortage, I suggest the addition of fermentation alcohol to gasoline, in amounts of 5 to 30 percent. Ethyl (grain) alcohol has an octane number of 99; and a 50 percent blend of alcohol and 70-octane gasoline has an octane number of 88 (*1*).

In 1936, many European countries had laws requiring the blending of alcohol with motor fuel (*2*). The amount of alcohol required ranged generally from 10 to 33 percent. In the Philippines, a blend of 70 to 96 percent alcohol and gasoline was required (sugar was fermented to obtain alcohol). Some countries required the alcohol to contain 10 percent methyl (wood) alcohol, which also is a good motor fuel blending agent.

Jaffe (*3*), in 1940, noted that "The blending of ethyl alcohol with gasoline as a fuel for internal combustion engines has been practiced in several of the European countries for many years. Shortage of gasoline compelled this action. . . . The usual blend is about 10 to 30% ethyl alcohol added to gasoline. . . . The consumption of power alcohol in Europe in 1937 amounted to more than 500,000 tons." This was all before Arab petroleum came to Europe.

Sources of fermentation alcohol include molasses (obtained in refining sugar), barley, beets, rye, corn, malt, rice, potatoes, and raisins. Other chemical compounds, useful as gasoline blending agents, are isopropyl alcohol, acetone, and so forth, but I believe that ethyl alcohol is the cheapest and the most easily produced.

Adding alcohol to gasoline would help make the United States self-sufficient in energy and would build up an industry which could be expanded hurriedly in case of emergency. It would also help to forestall gasoline rationing.

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References

1. W. H. Hubner and G. Egloff, *Oil Gas J.* **36**, 103 (1938).
2. Anonymous, *Ind. Eng. Chem. News Ed.* **14**, 278 (1936).
3. B. Jaffe, *New World of Chemistry* (Silver Burdett, New York, 1940), p. 587.

Copyright Decision

With little fanfare in the media, the U.S. Court of Claims ruled on 1 December 1973 in favor of the National Institutes of Health and the National Library of Medicine and against the Williams & Wilkins Company of Baltimore, Maryland, publisher of a number of small medical journals. At issue was the photocopying and distribution by the federal government of published and copyrighted materials without the payment of one cent to either the authors or the publishers. This ruling places in jeopardy the whole copyright system for scientific and technical journals published in the United States. It enables the National Library of Medicine, and, by extension of the principle, almost any federal information agency,