Methionine and Lysine (93S7)

Natural alpha-amino acids are of fundamental importance to all life. They are the building blocks of primary peptides and proteins and play an essential role in animal nutrition and as part of many chemicals having powerful regulatory and other roles in living organisms. All the alpha-amino acids except glycine exist as two or more optical isomers and it is almost invariably the L-isomer that is physiologically active. For example, medicinal or diet supplementary amino acids other than glycine must be supplied as L-isomers. The notable exception is methionine, one of the primary protein amino acids, which is easily converted into the L-form in the body. This requirement for the L-form is a strong constraint on the manufacturing techniques for amino acids and has tended to favor biosynthesis or extraction from natural products. Some processes make use of optically specific enzymes to catalyze one or more reaction steps in a mainly synthetic chemical route. Stereospecific synthesis may be a possibility in future L-alpha-amino acid manufacturing routes.

Prior to the second world war, industrial production of amino acids was confined to hydrolysis of natural proteins followed by separation of the individual amino acids, an expensive route. Degussa pioneered commercial production of synthetic DL-methionine in 1948 in Germany. The first commercial production of amino acids by microbial means was pioneered by Kyowa Hakko Kogyo Company in Japan, which first produced L-glutamic acid by this route in 1957 and L-lysine in 1978.

Since then, the manufacture of amino acids has become a major industry. The main uses include food additives and flavor enhancers, animal feed additives, artificial sweeteners, and numerous uses in pharmaceutical, medical, and cosmetics fields. However, only three amino acids are in large scale production, comprising about 98 weight percent of total world amino acid production of about 750,000 metric tons per year: L-glutamic acid (sold as monosodium glutamate, MSG), DL-methionine (and its hydroxy analogue, MHAn), and L-lysine (sold as L-lysine monohydrochloride). This study is concerned with the manufacture of methionine and lysine and their large volume markets, overwhelmingly as supplements in animal feed formulations.

Enormous literature has been developed on routes to feed grade methionine and lysine, including patents, papers, and books. However, the details of processes actually used, and of the performance achieved by specialized microorganisms developed for lysine production, are closely guarded industrial secrets, usually not even published in patents. It has been necessary to develop somewhat speculative process designs in order to estimate economics of major manufacturing routes, based on chemistry and engineering principles and limited published information.

All the economic assessments of this study are based on the concept of new plants built on greenfield sites in the United States, operating at full capacity in 1994. Methionine and MHAn capacity for the various processes examined is standardized at 22,700 metric tons of equivalent DL-methionine per year, which is medium sized by current standards. The effects of methionine/MHAn plant scale on economics are reported. Lysine is manufactured almost exclusively by fermentation processes. A very large plant size, 56,700 metric tons per year of L-lysine monohydrochloride, was selected to reflect the influence of Archer-Daniels-Midland's new plants in the United States. Hypothetical competition is provided by the Toray route, a semi-synthetic route used in only one small plant in Japan. A huge scale-up of the Toray process to the same size is hypothesized, and a dedicated plant assumed on the same site to produce an intermediate, cyclohexanol, on a matching scale. Again, the effects of lysine plant scale on economics are reported.

The world's supply of methionine and MHAn is dominated at present by four major suppliers (Rhône-Poulenc, Degussa, Sumitomo Chemical, Nippon Soda) and their subsidiaries and joint venture partners who are all in fierce competition with each other in oversupplied home and export markets.

Reported lysine capacity shows an interesting change in pattern with other regions now having similar capacity to Western Europe and Japan, both of which are expected to remain fairly static in production capacity until 2000. Thus other regions may account for up to a third of world capacity by 2000, with only the United States among the traditional producing countries still expanding production, probably because of its good raw material position, especially for dextrose from corn starch. Lysine demand and capacity should come into better balance in the next few years, relieving some of the extreme downward pressure on lysine prices experienced in 1992/1993.