Alpha Olefins (98/99-7)

The conventional route to linear alpha-olefins (LAO) is via oligomerization of ethylene using an alkylated metal catalyst. By this method a wide spectrum of LAO products having even-numbered carbon chain lengths are coproduced.

The three largest producers of LAOs via ethylene oligomerization are Shell, Amoco, and Chevron, however they do not often license their technology. The technologies employed yield a relatively fixed range of products having a distribution that does not match the pattern of market demand. Demand is growing fastest in the C_6-C_{10} range. Therefore, a major challenge for producers has been to control the oligomerization process and/or incorporate other processes in order to best tailor output to market demands.

Sasol has now become the fourth major producer of LAOs (currently C_5s and C_6s and recently C_8) via recovery from coal based hydrocarbon streams. By the nature of its technology, Sasol can select individual products and capacity within the limits set by the raw gasoline feedstock composition and production rate.

The object of this report, in addition to updating the processes cited above, is to examine new routes to LAOs from Phillips, IFP, and UOP based on publicly available information and develop speculative economics for comparison with the existing routes to LAO.

Phillips has developed a family of chromium based catalysts, which can selectively trimerize ethylene to hexene-1 with 95 percent selectivity. In order to achieve such high selectivity a fundamentally different chemical pathway must be at work. The key difference between this new catalyst system and conventional oligomerization catalyst is the propensity of the Phillips chromium based catalyst to form metallacycles, as shown on the next page.

The first metallacycle formed is a five membered ring structure comprising two equivalents of ethylene. Five membered rings are thermodynamically relatively stable structures and remain intact long enough for another equivalent of ethylene to be inserted thus affording a seven membered metallacycle. At this stage in the catalytic cycle the seven membered ring structure decomposes via reductive elimination, in preference to forming a relatively unstable nine membered ring, and releases one equivalent of hexene-1 and an active catalyst poised to repeat the cycle.

UOP is offering for license a LAO process called Linear-1™. The process is based on a novel class of ligands, which, when forming a complex with a transition metal, can be activated with a hydride to generate an active catalyst for ethylene oligomerization.

UOP claims that the Linear-1™ process is flexible and can be operated between the Schulz-Flory constants of 0.55 and 0.67 by making simple adjustments to the operating parameters. This results in varying the C_4 to C_{10} products from 59 to 80 weight percent.

IFP is also offering a new LAO process for license. IFP's AlphaSelect™ process is an oligomerization process that operates in the liquid phase using a proprietary soluble catalyst system. The catalyst system is composed of a catalyst and a cocatalyst. The ratio of these two can easily be varied and tightly controlled to permit different production distributions.

IFP claims that the catalyst system is nontoxic and there are no heavy metals of group VIII metals employed. The spent catalyst is oxidized to eliminate residual hydrocarbons. The resulting solid oxide material is nontoxic and easy to handle. The catalyst employs a solvent that enables the isolation of all the various alpha-olefins constituents, even those above C_{12} if desired, although the technology is oriented toward producing alpha olefins for polyethylene comonomers (C_4-C_8), plasticizer alcohols (C_6-C_{10}), and poly alpha-olefins (C_8-C_{12}).