Ziegler-Natta Reaction Encyclopedia Article

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Ziegler-Natta Reaction

The revolutionary Ziegler-Natta reaction involves the catalytic polymerization of unsaturated hydrocarbons (alkenes) to yield non-branching, linear polymers. These polymers are known as *high-density*on account of their superior strength and high crystallinity. Indeed, high-density **polyethylene** (HDPE) is invaluable as a household plastic and high-density **polypropylene** (HDPP) as carpet fibers, amongst other innumerable applications. Professor **Karl Ziegler** in Germany accidentally discovered the Ziegler-Natta catalyst in 1953. Equipment from a previous experiment had not been cleaned thoroughly before a polymerization of ethylene and unexpected results were observed. After careful investigation a **nickel** residue was found and sparked the painstaking search for an ideal catalyst. The optimum catalyst was found to be a **solution** of **titanium** tetrachloride and triethylaluminium. The Italian chemist **Giulio Natta** successfully applied the catalysts to polymerize propylene. Furthermore, Natta investigated the spatial orientation of side-groups, or branches, in the new polymers. Traditional polymer synthesis results in the random (atactic) location of the side-groups either to the left or right of the polymer chain. However, the Ziegler-Natta catalysts yield polymers with all the side-groups positioned on the same side (isotactic) and thus, permitting the industrial synthesis of materials with properties identical to natural rubber. This extremely desirable structure owes its elasticity to the isotactic nature of the polymer, and for this reason these polymers are used for the manufacturing of car tires. The catalysts had revolutionized the polymer industry within ten short years and in 1963 Ziegler and Natta shared the Nobel Prize. The catalytic mechanism itself is chemically complex and while a number of theories have been proposed, it is still not entirely understood in 1999. The original catalyst was improved in the early 1970s by employing a **magnesium** dichloride support that dramatically increased catalytic activity and further minor modifications have been made since then. Homogenous metallocene catalyst of ethylene and propylene polymerization were discovered in the 1980s, and their application to the synthesis of new **plastics** remains an intense area of research.