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ORIGINAL RESEARCH

The effect of different process parameters on the $TiCl_4$/internal donor/$MgCl_2$/$AlEt_3$ catalytic system using external donor and cyclohexylchloride

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Abstract
In this work, the effects of different process parameters were investigated on the performance of $TiCl_4$/internal donor/$MgCl_2$/$AlEt_3$ catalytic system and produced polyethylene in a semi-batch stirred reactor. Various methods such as Brunauer–Emmett–Teller (BET) surface area analysis, scanning electron microscope (SEM), sieve shaker and melt flow index (MFI) measurement were used to investigate the catalyst activity and final polyethylene product. The results showed that cyclohexylchloride as promotor, in the presence of external donor, increased the catalyst activity up to 110% at optimum ratio to titanium. On the other hand, the polymer particle size and fine particles, which were directly related to the catalyst activity in the most cases, increased up to 15% in the presence of optimal halocarbon/Ti ratio and decreased up to 45% using hydrogen in the studied range. Also, in the optimal ratio, cyclohexylchloride increased the active site concentration and as a result, the MFI increased significantly. Also at low agitator speeds, due to low heat and mass transfer, the catalyst particles were severely fragmented and the particle size was decreased clearly. The results also showed that due to the special catalyst structure, pre-polymerization with propylene increased the catalyst activity by approximately two times compared to ethylene pre-polymerization.

Keywords Ziegler–Natta · Polyethylene · Cyclohexylchloride · Pre-polymerization · External donor

Introduction

Polyethylene as the most widely consumed polymer in the world is manufactured in a variety of products such as low-density polyethylene (LDPE), high-density polyethylene (HDPE), medium-density polyethylene (MDPE), linear low-density polyethylene (LLDPE) and ultrahigh-molecular weight polyethylene (UHMWPE) [1]. It is also available in different grades of pipe, film, blow molding, injection and fibers which vary in molecular weight (M_w), molecular weight distribution (MWD), additive types and density [2].

Ziegler–Natta catalysts are more complicated now than the one which was invented seventy years ago by Ziegler and Natta [3]. The new catalysts have based on a variety of catalyst metals, cocatalyst, supports, internal and external donors, promotors and also preparation methods. The modern catalysts have high ability to produce more complex polyolefins with fewer processing difficulties during production, including fine, wax and fouling and also excellent processability, high physical and mechanical properties and low cross-linking degradation in extruder [4, 5].

One of the special catalysts in commercial polyethylene plants is based on $TiCl_4$ supported on magnesium chloride which produced spherical and coarse polymer particles compared to usual catalysts [6]. The production of spherical magnesium chloride as Ziegler–Natta catalyst grade has its complexities such as low impurities, acceptable mechanical strength and resistance to high fragmentation during catalyst preparation and polymerization to prevent fine production [7].

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