

CHAPTER I

INTRODUCTION



1.1 Business growth review

Growth of polypropylene (PP) business over its nearly 40 years of existence has been the most vigorous in plastics history. The PP business began with the entrepreneurs; decisions to invest in production capacity were based largely on the faith that this new material would eventually have attractive markets, rather than on any established uses. Early results were not disappointing: the combination of an easy molding resin with properties intermediate between those of polyethylene (PE) and polystyrene (PS), but with high temperature resistance, permitted rapid penetration of many applications [1].

Commercial exploitation was very rapid with isotactic polypropylene (iPP), commonly known as PP, which is one of the most important commodity polymers. Since the first commercial inception in 1957, the increase in PP consumption rates has been high due to its versatile uses in areas such as fibers, films and injection moldings [2]. Following its explosive early growth, the PP business has maintained surprising vigor; its growth rate for U.S. production has remained above 7% in the last two decades, as shown in Figure 1.1. The recent and projected production of all major plastics, worldwide, are illustrated in Figure 1.2 and Table 1.1. Although linear low density polyethylene (LLDPE), taken alone, shows the highest growth rate. The growth rate of the closely related low density polyethylene (LDPE) and LLDPE businesses combined is slightly lower than that of PP, which, therefore, is projected to be the fastest growing major plastic in the '90s, at 6.9% per year [3]. Also apparent from Table 1.1 are the very high growth rates expected in those areas of the world outside of North America, Western Europe, and Japan.

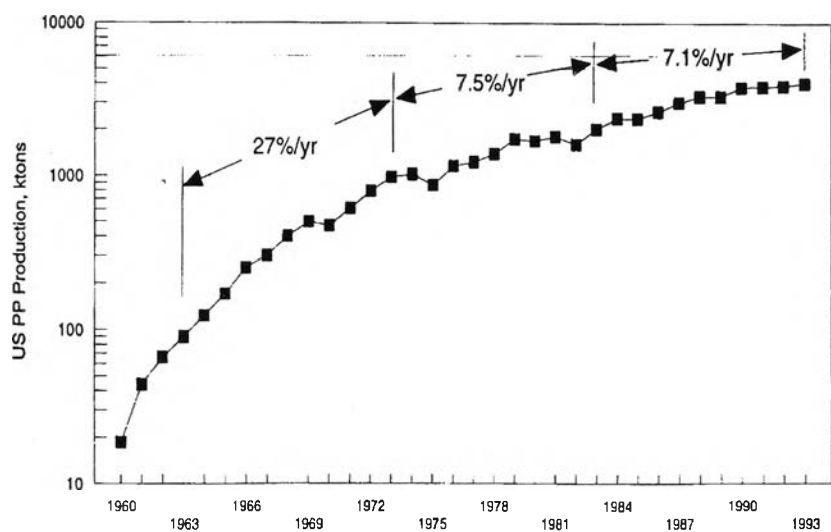


Figure 1.1 U.S. PP production, 1960 to 1993. Source: U.S. international trade commission.

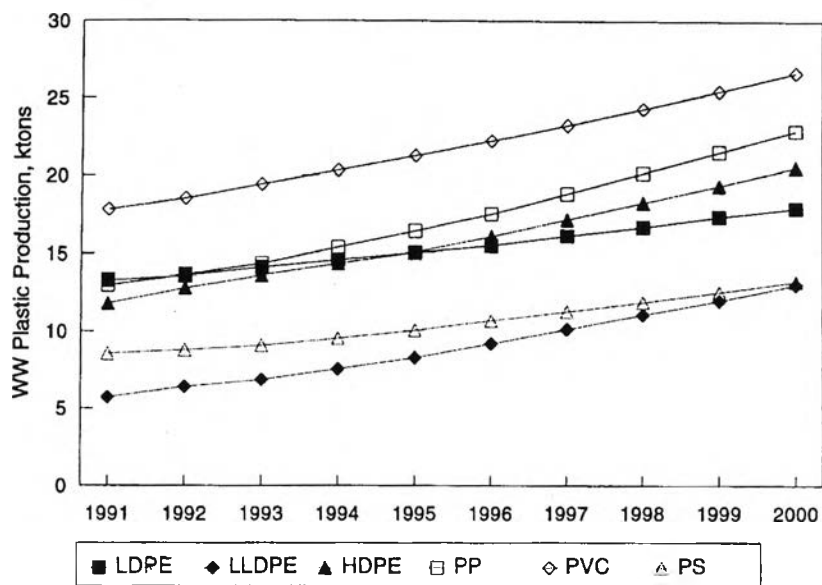


Figure 1.2 Worldwide plastics production. Source: modern plastics encyclopedia [3]

Table 1.1 Worldwide plastic production growth rates, 1993-2000 (growth rates compounded, % per year)^a

World region	PP	LDPE	LLDPE	HDPE	PS	PVC
N. America	3.8	2.2	4.1	3.4	2.9	2.2
W Europe	5.2	1.5	5.5	4.6	3.3	2.2
Japan	3.1	2.8	7.8	3.8	3.3	2.6
Rest of Asia	11.2	5.9	11.2	12.2	9.8	8.0
Rest of world	16.1	7.3	20.4	10.9	11.8	8.3
Total	6.9	3.5	9.7	6.1	5.6	4.6

^a Compound rates derived from the arithmetic rates in the source
Source: Mod. Plast. Encycl. [3]

Of course, much of the reason is the low starting point; those areas are consuming very little of any plastic at this time. The per capita consumption of PP follows the same pattern as all other plastics, seen in Table 1.2; the developing areas consume about one-tenth that of the three major regions. In spite of the rapid growth in the consumption, the developing areas are expected to move to only about 20% of the major three in per capita consumption by the year 2000. While that does not appear to be too impressive, the effect on the distribution of production capacity is.

The expected increase in worldwide PP capacity, shown in Table 1.3, anticipates continued vigorous growth for PP. However, the growth in the developing regions is even more dramatic. From virtually nothing in 1985, capacity in the "Rest of Asia" region (excluding Japan) is expected to become the largest producing region in the world around 1998. The "Rest of the World" shows a similar growth pattern, although at a lower volume level. Significant competition can be expected from these new installations.

Although the simplification of the PP process in the mid 1980s, with the lower investment costs, helped promote this proliferation of capacity, the increased availability of monomer supply was also critical to allowing this relocation to occur. In addition to the PP capacity itself moving overseas, and the consequent loss of export business, increasing numbers of fabricated items are being manufactured in the developing countries using the newly available PP from domestically [4].

Table 1.2 Plastic production, kg per capita, 1993

World region	PP	LDPE	LLDPE	HDPE	PS	PVC	Total
N. America	10.2	9.8	7.5	13.6	7.2	12.6	61.3
W Europe	9.7	11.2	1.87	7.8	5.3	12.1	47.7
Japan	15.7	7	5.03	8.1	10.9	16.7	63.2
Rest of Asia	1.07	0.65	0.62	0.81	0.54	1.7	5.4
Rest of world	0.94	1.95	0.87	1.15	0.92	2.63	8.2
Total	3.25	3.19	1.55	3.08	2.04	4.39	17.5

Source: Mod. Plast. Encycl. [3]

Table 1.3 Worldwide polypropylene capacity

World region	1994		1998		Growth rate
	Capacity ktons	% of total	Capacity ktons	% of total	% per year
N. America	5,334	26	6,313	23	4.3
W Europe	5,568	27	6,618	24	4.4
Japan	2,649	13	2,979	11	3
Rest of Asia	4,250	21	7,310	27	14.5
Rest of world	2,691	13	4,321	15	12.6
Total	20,492	-	27,541	-	7.7

Source: Montell USA Inc.

Because of the lower labor costs in the developing nations, those fabricated goods provide even more effective competition than would unprocessed resin. Such items are being exported to the developed countries, reducing the PP demand for local manufacture. Thus, these changing patterns in world production can be expected to provide increasingly strong competition for PP producers in North America, Western Europe, and Japan.

1.2 Influence of β -PP, particularly heterophasic copolymer or PP/EPR blend on industrial applications

Based on consumption growth of PP resin as shown in Section 1.1, it was obviously seen that PP is one of the most important commodity polymers, widely used in technical applications. When a worldwide need to reduce unit weight accelerated their development and/or improvement. Early targets were metal, rubber, and glass components, all of which contributed heavily to the weight of the vehicle. Replacing these parts with a lighter material like PP provided immediate weight savings with no loss in performance. Especially, among the many applications for PP in automotive sectors, both exterior and interior trim, are door panels, kick panels, angel wings, arm rests, pillar covers, consoles, bumper, etc. Probably the most widely known PP automotive part is the battery case which switched from hard rubber molded to PP/EPR blend in order to reduction in weight and cost. Current attempt to upgrading end-used PP products would absolutely involve improvement of molecular weight, filler addition and modification of polypropylene structure. Structure modification of PP is largely based on developing and/or controlling its crystal structure, giving rise to the final desired properties. Hence, it is very important to investigate modifications of PP/EPR blend by addition of specific nucleating agents which can influence the formation of the β -crystalline form and finally gives rise to the superior impact strength of the final products in order to satisfy the end-users.

1.3 Research Objective

The main purpose of this study is therefore focused on studying the effect of selected β -nucleators (bicomponent of pimelic acid and calcium stearate) on crystalline structure and mechanical properties of PP/EPR blends.

1.4 Scope of the research

The scope of this research work includes:

1. Survey of literature and supplied source of the selected β -nucleator.
2. Preliminary investigating the effects of various nucleating agents (including the selected β -nucleator) on mechanical properties of PP and PP/EPR blends.
3. Preparation of resin compounds by blending Heco PP with the selected β -nucleator at various ratios using twin-screw extruder.
4. Study effect of converting from α to β crystalline form on the resulting pelletized extruder blends in terms of mechanical properties, especially impact strength of β -form Heco sample (β -H sample).
5. Evaluation of the thermal properties of β -H sample using differential scanning calorimetry (DSC).
6. Observation of the morphological structure of β -H samples using scanning electron microscopy (SEM) technique are also carried out.
7. Verification of the β crystalline form correlate to degree of crystallinity of β -H samples using wide-angle X-ray diffraction (WAXD) technique.
8. Summarizing the results including discussion.