Carbon dioxide is the main greenhouse gas, but it is also a renewable and abundant source of carbon. It has not only shown various physical utilization in the manufacturing of food, beverage and other industry areas, but been chemically fixed into urea, salicylic acid, organic and inorganic carbonates (Mikkelsen, Jorgensen & Krebs, 2010). However, developing a high value-added fixation route to CO$_2$ is badly needed.

In 1969, Inoue discovered that CO$_2$ could be fixed into aliphatic polycarbonates via alternative copolymerization with epoxides (Inoue, Koinuma & Tsuruta, 1969) such as ethylene oxide, propylene oxide, and cyclohexene oxide. Among all the aliphatic polycarbonates, poly(propylene carbonate) (PPC) shown in Scheme 1 had the biggest opportunity for commercialization, in that it is cheap since it contains over 40 wt% CO$_2$, and its biodegradability makes it valuable to solve the high cost problem of the biodegradable plastics industry puzzled since its birth.

Although PPC was discovered in 1969, its commercialization has been far from successful, as it is suffered from the following three obstacles.

1. low catalytic activity leading to high cost;
2. low molecular weight (of polymer) resulting in poor thermal and mechanical performances;
3. long polymerization time causing low production capacity.

The catalyst is the driving force of developing industrially viable PPC. Since 1998, researchers with the Changchun Institute of Applied Chemistry (CIAC), Chinese Academy of Sciences has developed a special rare earth ternary catalyst, which was capable of producing high molecular weight PPC with relatively high catalytic activity in short reaction time (Liu et al., 2001). Therefore, CIAC obtained two US patents, one Japanese patent and six domestic patents for the catalyst as
well as for the processing of PPC.

Licensed by the CIAC, Mengxi High-tech Group in Ordos City, Inner Mongolia built a pilot line in 2004 to produce 30 tons of PPC each month, which is still running now. It was noteworthy that the CO\textsubscript{2} used was captured and purified from the exhaust gas of cement kilns, and the PPC was produced with a glass transition temperature (\(T_g\)) of ca. 35°C and number average molecular weight (\(M_n\)) of over 100 kg/mol. This pilot line proved for the first time that large volumes of high molecular weight PPC can be produced in an economically viable manner.

In 2004, CIAC licensed its patents to China National Offshore Oil Company (CNOOC), and a 5000 ton/year production line was built in 2009 in the Dongfang City of Hainan Province (Figure 1). The CO\textsubscript{2} used was from the capture and purification of waste gas from the urea industry. Encouraged by these successful practices and a growing demand for biodegradable plastics, China has recently become very active in pushing the industrialization of PPC; several production lines for tens of thousands of tons’ production are currently being built.

Though PPC is biodegradable and cost viable compared with other biodegradable plastics, its thermal and mechanical performances will finally decide whether it can be commercialized in large scales. PPC is an amorphous polymer with low glass transition temperature (\(T_g\)). It is different from crystalline polyethylene or polypropylene with low \(T_g\), or amorphous polystyrene with high \(T_g\). Therefore, the as-polymerized PPC loses mechanical strength to result in poor dimension stability above 40°C, and becomes brittle below 20°C.

During the past decade, great efforts have been spent to improve the thermal and mechanical performances of PPC — “reinforcing at high temperature and toughening at low temperature” by enhancing intermolecular interactions via raising its molecular weight (Tao et al., 2006a), or introducing cross-linking structure (Qin et al., 2007; Tao et al., 2006b), or introducing crystalline structure (Zhou et al., 2009), etc. PPC master batch suitable for film-browning has been prepared, and PPC films in thousand-ton scale have been yielded. The mechanical strength of the PPC film is comparable with high density polyethylene (HDPE), and the 18\(\mu\)m films show dart ball impact strength of 120g, which is well suitable for the film industry. In addition to film making, PPC can also be processed into foam, pipe, sheet and so on.

The commercialization of PPC is extremely attractive since it may be the very solution to the high cost problem which is a longstanding puzzle for the biodegradable plastics industry. However, industrial tests remain in the preliminary stages, and uncertainty of whether or not the polymer is cost- and performance-viable with common polyolefins still exists. Catalyst research is the core issue in this area (Coates & Moore, 2004; Qin & Wang, 2010), since the catalytic activity is still 2-3 orders in magnitude lower than the Ziegler-Natta or metalloocene catalyst now widely used in olefin. In addition, the comprehensive thermal and mechanical performances of CO\textsubscript{2} copolymers are far from satisfactory. Therefore, the building of a new catalyst system with higher catalytic activity and improved polymer performance is the main target in this area.

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