Developing Commodity Plastic with Strength of Steel

As part of Promoting Technology Transfer and Innovation by the Japan Science and Technology Agency (JST), Prof. Masamichi Hikosaka and Dr. Kiyoka N Okada at the Graduate School of Integrated Arts and Sciences, Hiroshima University, have succeeded in developing a sheet-type recyclable ultrahigh-performance commodity polymer material (commodity plastic) at a low cost that has a specific strength higher than that of steel and is light enough to float on water.

Prof. Hikosaka and his colleagues successfully increased the crystallinity of polypropylene, a typical commodity plastic, to nearly 100% by a unique crystallization method, in which a polymeric melt is cooled below its melting point then elongated (Figure 1). The tensile strength of polypropylene was increased at least sevenfold to 230 MPa, and the specific strength became two- to fivefold higher than that of steel (Table 1). Unlike expensive unrecyclable engineering plastics and fiber-reinforced plastics, the developed ultrahigh-performance polymeric material, isotactic polypropylene (iPP), has additional advantages: it can be molded as cheaply and easily as conventional commodity plastics and can also be recycled. The achievement of this research is attributable to a fundamental scientific finding, i.e., the elucidation of the mechanism of polymer crystallization achieved using SPring-8 by Prof. Hikosaka and his colleagues.

In the future, it is hoped that the achievements of this research will contribute to establishing a low-cost, energy-saving, resource-saving and low-carbon sustainable society by further developing this research and by promoting the use of the newly developed commodity plastic in Japan and overseas as an alternative to metals, ceramics, engineering plastics, and conventional commodity plastics, as well as automotive and industrial steel sheets. The research group aims at the practical application of the plastic in cooperation with companies participating in the joint research.

Reference:
Kiyoka N Okada, Jun-ichiro Washiyama, Kaori Watanabe, Sono Sasaki, Hiroyasu Masunaga and Masamichi Hikosaka, *Polymer Journal* **42** (6), 464-473 (2010)

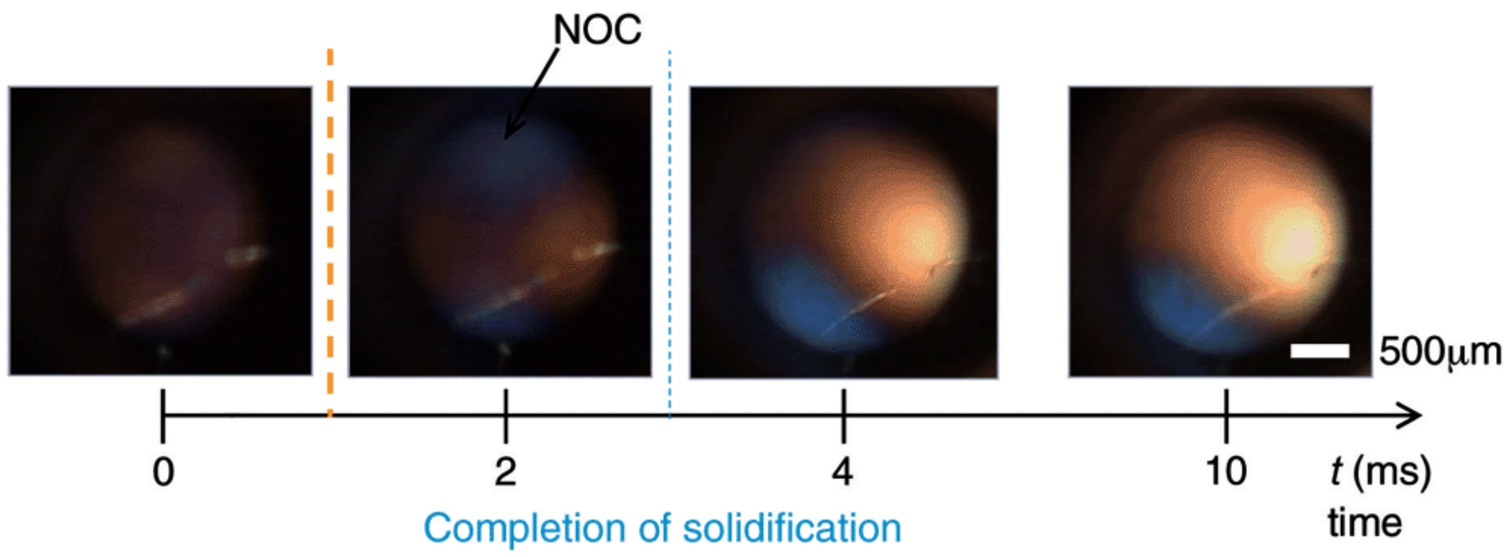

Figure 1. Formation of Nano-Oriented Crystals (NOCs)
The polarizing optical microscope images obtained using a high-speed camera show that NOCs are formed instantaneously when the polymeric super cooled melt is compressed at 150 °C. The blue and yellow areas are evidence of oriented crystallization. The rapid oriented crystallization of NOCs in only a few milliseconds was thus confirmed.

material	tensile strength σ_M (MPa)	specific gravity ρ	specific strength σ_R (MPa)
aluminum	100	2.7	37
brass	350	8.6	41
stainless steel	500	7.8	64
automobile steel	400 - 800	7.8	51 - 102
NOCs (developed iPP)	230	0.94	244

specific strength σ_R = tensile breaking strength σ_B / specific gravity ρ

Table 1. Comparison of specific strength among various sheets