Development of MCPOLYCA Reflector for LED Lighting

1. INTRODUCTION

The Micro Cellular Plastic (MCP) is a foam with 0.1 to 10 μm of micro cells diameter and closed cells with cell density is between 10^9 to 10^{15} cells / cm^3. The foam has been developed by professor Suh and others at MIT in USA. Initially this material has received a lot of attention as the cell has been very fine and the material weight has been reduced without decreasing mechanical characteristics (specific strength). Furukawa Electric started the development in 1990 and found out a superior optical performance. And then, polyethylene terephthalate resin (PET) based super micro foamed optical reflector (MCPET) was launched in the market, a first in the world.

Since the MCPET performance is characterized by light reflection and easy workability (bending, punching and cutting), the MCPET has widely utilized applications such as sign boards for advertising, facade boards for convenient stores and destination boards in railway stations etc. which offers brightness and energy saving. In addition, from 2009 due to increasing awareness of energy saving, the MCPET has been adopted as a reflector of fluorescent lighting for renovation application of office lighting, and has contributed to energy savings of office by reducing the number of fluorescent lamps (from 2 to 1). (Figure 1)

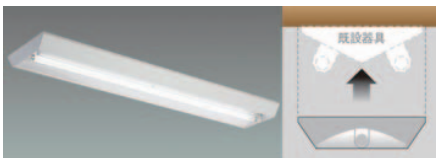

Figure 1 reFbo Light (from Daiwa House Industry catalogue).

On the other hand, the MCPET is a crystalline plastic and has a problem in thermo formability (forming condition range is narrow). Therefore, the development of the forming required application was difficult. Thus, we developed the polycarbonate resin based super micro foamed optical reflector (MCPOLYCA), by applying MCP manufacturing technology that can be applied to a variety of plastics. Non-crystalline MCPOLYCA is excellent in thermo formability, and expansion to Down light module for LED lighting is expected.

Overview of the MCPOLYCA and possible application to LED lighting are explained in this report.

2. CHARACTERISTICS OF THE MCPOLYCA

Figure 2 shows a cross sectional SEM photograph of the MCPOLYCA sheet. Generally, inorganic materials are added to solids (injection molded products) and films to increase light scattering. But, the MCPOLYCA contains only micro foams (hollow) in the order of few μm. By controlling dimension and quantity of this micro foam, a high light reflective performance, which is not available in other material, is obtained.

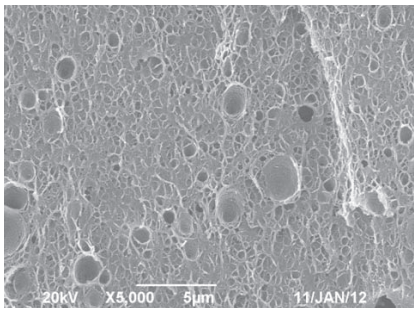

Figure 2 SEM photograph of the MCPOLYCA.

Table 1 show physical properties of the MCPOLYCA in comparison with the MCPET (RB grade) which is in sale for lighting and sign board application from Furukawa Electric. The MCPET shows some better mechanical characteristics than the MCPOLYCA, but the MCPOLYCA shows higher performances than the MCPET in diffuse reflectivity and thermal properties (thermal dimensional change rate, heat distortion temperature).

The excellent diffuse reflectivity is caused by embossed shapes given to the surface of the sheet. In case of the MCPOLYCA, the embossed shapes are easily given in manufacturing process, and remain without loosing the shape after forming. This is the feature of the MCPOLYCA. Heat distortion temperature was measured by thermo-mechanical analysis method (TMA method). The MCPET, which is a crystalline plastic, gradually starts softening at higher than glass-transition temperature of 75℃ and shows the behavior of a significant softening at higher than 200℃. On the other hand, because of the non-crystalline plastic feature, the MCPOLYCA starts softening at

glass transition temperature of approximately 140℃ without showing two steps of softening behavior. Judging from this behavior, the MCPOLYCA has higher applicability than the MCPET as a reflector material for LED lighting that requires 100℃ to 120℃ of heat resistance.

The MCPET (RB grade) has obtained UL94-HBF for fire retardancy. In-house test result confirmed that the MCPOLYCA had equivalent level of UL94-HBF to UL-94-V2. Fire retardancy is dependent on sheet density and thickness, and designing is required in accordance with the customer requirements. In addition, development is going on in consideration of future launching of UL94-V0 grade products.

Table 1 Properties of the MCPOLYCA and the MCPET (RB grade).

Item	Direction	Unit	MCPOLYCA	MCPET (RB)
Thickness		mm	1.0	1.0
Total reflectivity*1		%	99	99
Diffuse reflectivity*1		%	98	96
Tensile strength	MD	MPa	21	20
	TD		18	18
Elongation	MD	%	45	123
	TD		50	68
Tearing strength	MD	MPa	62	76
	TD		64	99
Bending strength	MD	MPa	15	19
	TD		14	14
Flexural modulus	MD	MPa	754	1156
	TD		698	882
Thermal dimensional change rate (100℃, 22h)	MD	%	0.23	0.37
	TD		0.18	0.24
Heat distortion temperature (TMA method)	MD	℃	143	75 (202)
	TD		144	75 (201)
Glass-transition temperature		℃	145	75
Fire retardancy		UL94	HBF～V2 *2	HBF

*1 : Reflectivity is the relative value against $BaSO_4$ white plate at 550 nm
*2 : Fire retardancy of MCPOLYCA is the in-house evaluated value.

3. FORMABILITY OF THE MCPOLYCA

The MCPET is necessary to be formed by match-mold forming method using two types of male and female metallic mold. The MCPOLYCA can be formed by vacuum forming method or vacuum and pressurized air forming method using one kind of metallic mold (male or female).

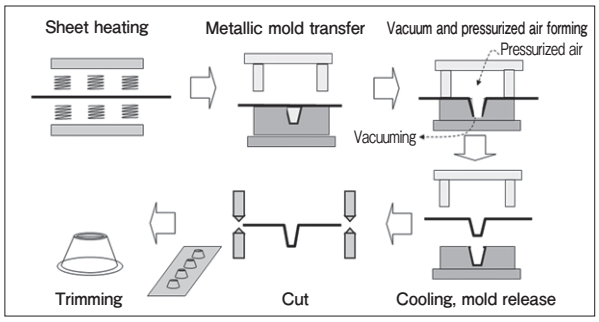

Figure 3 Vacuum and pressurized air forming process.

Figure 3 shows vacuum and pressurized air forming process. Depending on forming shape vacuum forming method can be used, but by using pressurized air method in combination, products can be formed with better shape transferability. Figure 4 shows a photograph of a cup shape formed product. Edge part shape is precisely created.

In case of the MCPET, certain duration of heat set is necessary for shape stabilization at the same time as the forming. This time is not required for the MCPOLYCA and the cycle time can be shortened.

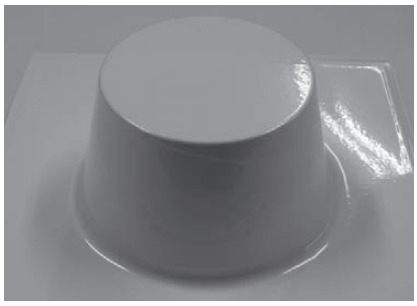

Figure 4 Vacuum and pressurized air forming sample of MCPOLYCA.

4. APLICATION TO LED DOWN LIGHT MODULE

Left side photograph of Figure 5 shows LED Down light module, which applies an MCPOLYCA, manufactured by A. Die processed goods of the MCPET are placed at the bottom surface of the module (die cutting in accordance with the placement of LED chip) and side (cylindrical shaped). This has a structure to emit uniform white light as LED light (blue) diffusely reflects at the yellow diffuser panel and repeat multiple reflections within the module. However, this structure has separated reflectors at the bottom and the side, and then from the assembling cost reduction point of view a formed product which integrates bottom and side reflectors is required. Right side photograph of Figure 5 shows LED Down light module manufactured by B. By aggregating LED chips to the center part of the base (modularization of the light source), inverted truncated cone formed product is possible to be

applied. Presently formed MCPET products are applied, but in accordance with modularization of light source heat increase becomes an issue, in parallel with the increase of the light amount. And then we expect that the demands for the MCPOLYCA with high heat resistant feature will increase.

Figure 5 Applications to LED Down light modules.

Down light module shown in Figure 5, which utilizes multiple LED light reflection by placing reflectors at aperture, is suitable for the MCPOLYCA application. Recently LED light source becomes possible to adjust the light emission to wide angle, by combining with the condenser lens. For this to happen, the reflector is essential, and the expansion into straight fluorescent type lighting and ceiling type lighting is expected.

5. CONCLUSION

In addition to the recent enhancement of energy saving awareness, as a consequence of the drastic change in power condition caused by catastrophe in 2011, the replacement of the traditional lighting to LED lighting is rapidly growing. One of the merits of LED lighting is the advantage of flexibility in designing to the traditional lighting. The MCPOLYCA can be easily formed by vacuum forming method or vacuum pressurized air forming method. Then metallic mold cost becomes lower than metal reflector and injection forming reflector. We think, this meets the needs of the lighting equipment of high-mix low-volume production because of the diversification of the lighting design. The MCP manufacturing technology developed by Furukawa Electric is not limited only to the MCPET and the MCPOLYCA, but also applied to the Poly Ethylene Naphthalate (PEN), the Poly Phenylene Sulfide (PPS), the Poly Ether Sulfone (PES) and a variety of high performance plastics. Furthermore, by taking advantage of not only light reflection feature but also light weight and high rigidity, this product is in sales as a material of speaker cone of mobile phones. We thrive to keep introducing MCP products meeting with customers needs.

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