Complex approach

A year into a project seeking to demonstrate the recyclability of multilayer flexible polyamide structures, Aimplas details its progress to **Steven Pacitti**

Multilayer flexible structures provide clear advantages compared with rigid or monolayer alternatives, in terms of adaptation and lightness, which make them ideal for transport and distribution, while reducing the product's carbon footprint.

Yet, their greatest benefit is undoubtedly their ability to increase food safety and extend product shelf-life, which in turn makes a sizeable contribution towards reducing food waste. However, these multi-material structures have generated controversy due to the difficulty in recycling them using current systems.

In Spain's Valencia region, the Recipam project was created to address this issue. The consortium of companies taking part include chemical manufacturer UBE, plastics formulator Repol, injection moulder Faperin, recycler Acteco, and Aimplas, which specialises in plastics materials research.

"The project studies the recyclability of multilayer flexible structures containing polyamide in both industrial and household waste; in other words, pre- and post-consumer waste," explains Chemical Recycling Group leader and sustainability expert at Aimplas, Eva Verdejo. "Results thus far have demonstrated that these structures can be recycled, thanks to minor modifications in the industry itself. This also means that recycled material can be included to produce real products."

To achieve these results, recycling was followed by different transformation processes (see Fig.1).

In the first phase of the project, two different kinds of pre-consumer waste were used: PE and polyamide (PA), as well as PP and PA, with different proportions of the latter. This waste was subject to a recycling process at Aimplas's pilot plant, where the processability and feasibility of the materials obtained were evaluated on the basis of small-scale output.

The waste was then subject to a traditional industrial recycling process at Acteco Productos y Servicios (see Fig.2).

"Recycling conditions were like those used in the industry for recycling pre-consumer single-material waste, so it was not necessary to significantly modify the process," explains Verdejo.

UBE then processed the recycled material obtained in pellet form. The blown film extrusion process was selected at very thin gauges (50 and 120 microns) because both the process and the thickness would make any defects in the material easily detectable.

"Different single-layer and multilayer films containing up to 50 per cent recycled material (PA or PE) were processed, and were observed to perform consistently in all process parameters," adds Verdejo. "The different films obtained from this process showed good mechanical properties. Moreover, when recycled material was used to replace virgin PE in multilayer structures, higher values were obtained, which shows that recycling can improve the final properties of these materials and, therefore, has industrial applications.

Figure 1: Transformation processes

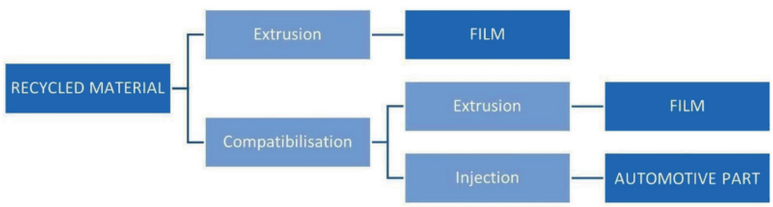
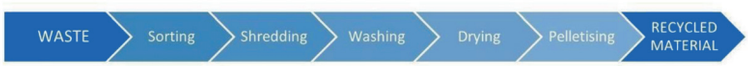


Figure 2: Recycling process



"In addition, when the percentage of PA in the recycled material was higher, most of the properties of the new film were not noticeably different. A comparison of a 100 per cent virgin PA film and one of the project samples containing recycled PE/PA showed no difference."

Although the results were good, the decision was made to test the use of compatibilisers because the recycled material contained two incompatible polymers, which created a phase problem that could be improved by using these specialist additives. Repol added virgin PA to obtain blends with different percentages of recycled material and compatibilisers, which were then injected to obtain specimens for characterisation.

"The compounding and injection parameters were adjusted," continues Verdejo. "Some parameters, such as extrusion temperature, shear and production speed, were modified without changing the screw design, thus proving that these processes are easily scalable at industrial level. The blends obtained demonstrated stable rheological performance and their mechanical properties were similar to those of flexible PA6."

Using the new compatibilised formulations in blown film extrusion, improved tear and puncture resistance was observed when virgin PA was used, as well as a decrease in opacity that translated into better optical properties compared with non-compatibilised films.

When virgin PE with up to 75 per cent compatibilised recycled material was added, no improvements were observed in mechanical properties, but there was in optical properties.

"These results were obtained by using the same equipment and screw design as those used with virgin materials," adds Verdejo. "For recycled materials, the use of a PA temperature profile improved film tensile strength and reduced gels, resulting in high-quality film through machine adjustment."

Faperin conducted injection-moulding tests with recycled materials using industrial equipment. The first tests performed with a PE base and 100 per cent PA showed good material processability and good part demoulding.

"Together with previous findings, these results prove that recycled materials from multilayer flexible films are suitable for both injection and extrusion," Verdejo says. "The project is currently working with post-consumer waste, and initial results are promising."

As a result of the work done on the project thus far, it is now clear that multilayer film waste with PA can be recycled at an industrial level. This will not only reduce landfill and clearly help to recover resources, but will also reduce carbon emissions. This is a significant reduction, explains Verdejo, given that emissions are reduced by 25 per cent by using 50 per cent recycled material, compared with the production of the film using virgin materials.