Plastics with new properties

How scientists from the Fraunhofer IMWS in Halle are learning from nature

Leonardo da Vinci had the idea of learning from nature and applied the technique of the flight of a bird to his flying apparatus. That was more than 500 years ago. Today, however, the term “bionic” applies to the application of nature in the field of technology. Scientists from the Fraunhofer IMWS in Halle have also been using the example provided by nature for the development of plastics with new surface properties.

“The lotus effect is a classic part of bionics,” explains Annika Thormann. “Droplets of water roll off the leaves of the lotus plant without leaving any residue and absorb dirt particles from the surface at the same time.” How does this happen? “It is because of the surface structure of the leaf, which is covered by wax crystals in the size range of a few micrometres which reduces the surface area,” explains the scientist, who also has a contrasting example from nature to hand, the "Gecko phenomenon". Geckos are able to attach themselves to smooth surfaces when they are upside down. Extremely fine hairs and fins on their feet enlarge their surface and enable an interaction at the molecular level.

This prompted the scientists at the Fraunhofer Institute for the Microstructure of Materials and Systems IMWS in Halle to transfer micro- and nano-structures of this kind to the surfaces of plastics. Depending on their structure, they can be given water-repellent and adhesive properties. Micro- and nano-structured surfaces of this kind are created via an embossing process which was developed at the Fraunhofer IMWS and has now been patented.

Annika Thormann shows us matt-silver embossing dies made from aluminium. With the naked eye it is almost impossible to see the fine structuring of their surface. “The cavities are only a few micrometres in size and are created with laser ablation. In a second step, 20 to 300 nanometre-sized pores are formed through anodic oxidation,” she explains. “The micro- and nano-structures on the dies are then transferred to thermoplastic synthetic films or panels during the hot embossing process which we developed. This means that the surface properties can be appropriately adapted to the use of the plastic on a targeted basis.”

There is enormous commercial potential in the trenches, troughs and cavities on the surface of the die. Efforts to expand the properties of plastics and improve the end products made of plastic are under way all over the world. Annika, a graduate engineer, is conducting research in the field of polymer applications. She tells us that if they were used in medical technology, for example, surface-treated plastic implants could connect better with the human tissue. Specialist properties are also considered desirable for packaging films or for films which are used in agriculture.

From the point of view of environmental protection, new strategies for the sustainable use and the recycling of plastics are also needed, adds Prof. Dr. Andreas Heilmann. Andreas Heilmann leads the business unit for “Biological and macromolecular materials” at the Fraunhofer IMWS. He jokingly tells us that he thinks plastic film is one of mankind’s most important inventions. He believes that the packaging film with its new surface properties, in particular, offers great market opportunities. Adhesive-free labels or inks, for example, could adhere better to this film. “Its direct refining without additives also improves its recycling capabilities,” highlights Andreas Heilmann.

The scientist is currently coordinating a research project known in German as KoMiNaKu, which means the "combined micro- and nano-structuring of plastics". The research partners are based in the local economy. The Halle-Bitterfeld-Merseburg “chemicals triangle” region of central Germany is traditionally home to the production of plastics and specialist mechanical engineering. The companies see great potential for improving their products with the new surface structuring technology. The cooperating partners are currently working together on optimising the micro-nano technology so that it can be implemented at the industrial level.

“The company FilmoTec GmbH from Bitterfeld-Wolfen, for example, is interested in using the new technology to further improve the bond between the underlay and the photographic layer of emulsion, so that archive films become more durable – if not eternally durable,” says Andreas Heilmann, before telling us that Polifilm GmbH could also choose to use the product. Polifilm, which is based in Weißandt-Gölzau, is interested in improving the bonding of adhesives and inks on its protective film and packaging film.

It goes without saying that machines are needed which implement the new technology. Companies MABA-Spezialmaschinen GmbH from Bitterfeld-Wolfen and SmartMembranes GmbH from Halle are interested in developing the corresponding components.

On seeing the scale of the embossing die in the experimental laboratory, however, those aware of the huge size of the rolls of industrial packaging films will rapidly reach the following conclusion: that it is necessary for other dimensions to be taken into account. “Our experiments have proven to be successful at the laboratory scale,” explains Andreas Heilmann. “They now have to be implemented in the form of a large scale, roll-to-roll process which is appropriate for industrial users.”

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Image caption: Scientists Annika Thormann and Prof. Dr. Andreas Heilmann present the embossing stamp with its combined micro- and nano-structures. It was developed at the Fraunhofer IMWS in Halle.

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