<인터뷰 전문>

Future plan:

Our two main research projects deal with microfluidic production of liquid crystal shells and electrospinning of liquid crystal- or colloid-functionalized polymer microfibers, and we are now pretty good at both these tasks. The next step is to bring these techniques to new uses, either technical applications or for new science. For the fibers we are aiming at wearable technology, meaning that we try to develop fiber mats that can be integrated in clothing and at the same time provide the responsive functionality that is typical of liquid crystals and colloids. The first activity in this direction is to make optical read-out gas sensors that are autonomous (they don't need any power source) and work at room temperature, which can be integrated in for instance a suit of a person working in an environment where there is risk of hazardous gas leakage. If the suit changes color s/he knows immediately that something is wrong. Minsik and Dae Kyom in our team are working on this right now, and they have some pretty cool results! Further on we want to explore more "crazy" ideas, primarily of artistic type. We will here be working with Prof. Younghui Kim at Hongik University, who is an artist specializing in bringing technology into clothing and wearable artworks. Our idea is to produce fiber mats that change for instance color, shape or stiffness as a function of temperature, pressure, stretching, atmospheric changes etc. and Younghui would then use her artistic freedom to incorporate these into wearable artworks that change appearance or feeling in response to a change in the environment, the mood of the wearer or certain activities of the wearer. For instance, a t-shirt that changes color when it gets stretched because you have eaten too much could be a pretty funny thing (at least for the people around the person wearing the t-shirt ;-).

In the project on the shells the next targets are still more of fundamental scientific nature. The nice thing with these shells is that they are soft and changeable but at the same time ordered. The order means, for instance, that we can introduce certain molecules, and the liquid crystal will make sure that they go into specific places on the shell. Depending on which liquid crystal phase we have (this can be controlled by changing the temperature a little bit up or down) we can change dynamically how many possible places there are and how they are arranged (this is the advantage of the softness). We are now working with synthetic chemistry colleagues who are trying to realize new molecules tailored for our shells, that effectively constitute "arms and hands". The "arms" will be anchored in the shell, at the locations dictated by the liquid crystal order, and they stretch out into the surrounding, ending with "hands" that can be for instance single-stranded DNA. Nature has designed this molecule so exquisitely that it spontaneously makes strong bonds to other single-stranded DNA that has the right build-up (so-called complementary strands) but not to others. This function is the basis for how our cells transfer information about who we are when they divide, and even for the transfer of information from parents to children, but exactly the same mechanism can be used extremely well in nanotechnology, for entirely different purposes. The order of the liquid crystal makes sure that the "arms" stick out from the shells in the right places, and not just anywhere, so when multiple shells hold hands, they will build chains or even more complex superstructures that are also ordered on a large scale. If the arms would be in random positions there could be bonding in any directions and we would get a pretty messy structure, but since our shells are made out of ordered fluids the hands can only stretch out in certain directions and then we can expect much more interesting superstructures arising. Since we can change the anchoring locations by changing the liquid crystal phase, we should be able to get the shells to "wave their arms" by changing the temperature. One of the most interesting possibilities is to get a diamond-like arrangement of the shells, that is in tetrahedral order (this is how the carbon atoms are arranged in real diamond). If the shells are reduced in size to below a micron in diameter (yes, I admit, this is a challenging task but not impossible!), and filled with a high refractive index material (for instance metal nanoparticles) then so-called "optical metamaterials" could be generated, with very unusual and useful properties. But this is really far in the future: for now we will be happy if we can get the shells to anchor molecules and particles the way we expect, and eventually to "hold hands" the way we want them! JungHyun is our expert on producing and investigating these shells and I am looking forward to see what she will produce when she gets her hands on new molecules and functionalized particles form our collaborators.

SNM group vision:

What I really like in research is when new and fascinating results come out of a fairly simple idea, often based on connecting different disciplines and applying knowledge from one field to another, and vice versa. This is really convergence science when it works best. It is one of the reasons why I try to keep a curious and open mind to many different fields, obviously primarily natural scientific ones since these are nearest at hand, but as I mentioned above I am very open also to more long-distance connections when I see an opportunity, for instance with art. Still, even within the natural sciences transdisciplinary work can be really challenging, because chemists, physicists and biologists often have extreme difficulties to speak a common language. It can be really tough to enter a new field, not necessarily because the science is so difficult but more because you don't know the jargon of that field and you may miss certain basic knowledge that everyone in that field takes for granted. An example is a project with JongHwan now, where both he and I are struggling to understand the chemistry of battery electrodes in order to combine it with our expertise on electrospinning. But I hope eventually, and with the help of friends and colleagues who complement my knowledge (in this case we will work together with Prof. Piao), we will achieve results that are both original and useful.

I often find that by mixing a bit of chemistry with a bit of physics, and sometimes adding a spice of biology, you can achieve really interesting and sometimes unexpected results. Soft matter is a perfect field for doing these types of transdisciplinary experiments, because you need the physics as well as the chemistry to understand how the nano- to microscale components of colloids, liquid crystals and polymers interact to give certain macroscopic properties, and biology provides some of the most interesting building blocks available (after all, most parts of our bodies and of all living beings are neither liquid nor solid, so we are in fact made out of soft matter!). I mentioned DNA above as a biomolecule that we will soon be working with, putting it to work within a context that is very different from its natural habitat. There is a lot of interesting liquid crystal-related science going on using microtubuli and actin filaments (these are rod-like structures building up the cytoskeleton of our cells, which can order up spontaneously in a liquid crystalline state under the right conditions), and the phase behavior of crowded biological environments like the cell or virus capsids, or even just the cell membrane in itself, is far from fully understood. It is very likely that we will be engaging in that type of research in the future. Another example of biomaterial that we are already working with is cellulose. Together with two Swedish groups and the labs of Prof. Scalia and Prof. Piao at the GSCST we are exploring new ways of getting cellulose nanocrystals (CNC) to self-assemble into large-scale ordered structures. CNC is a nice material because it is a bionanomaterial that is produced sustainably (our CNC is derived from wood) and it can self-assemble into liquid crystal phases with quite spectacular properties because of its rod-like shape and chiral molecular structure. This has already been used for producing transparent films with attractive optical properties (color that changes depending on how you look at it) and we hope to be able to use it for many more purposes, both in terms of stimulating research and applications.

In general, the vision for our research is to take relatively simple materials (often nanoscale) that are readily available (at best in nature, but buying commercially is OK as well) and get them to form new structures with new properties on their own. This is what self-assembly is all about. When you understand how it works, and you combine this with a cool original idea and the right building blocks , then magic results!