Determination of structure of polymer nanotextiles

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Before nanotextiles can find their place in civil engineering applications their properties must be carefully studied. Since these properties depend on the structure of the material, the determination of this structure becomes a vital task.

For our study we have chosen nanotextiles made of four polymers: PVDF (polyvinylidene fluoride), PUR (polyurethane), PAN (polyacrylonitrile), and PVB (polyvinyl butyral). Each of these polymers has some properties that can be interesting for civil engineering applications. The nanotextiles were produced at Czech Technical University in Liberec by NS 4S1000U device using Nanospider technology. For each polymer several samples have been produced with different speed of motion of supporting fabrics (10 – 50 mm/min).

In the first series of experiments we measured the surface density of our samples and have found its linear dependence on the speed of motion of supporting textile. This result is in a good agreement with theoretical modelling. That means, that if certain application requires nanotextile with a specific surface density, it is possible to predict the corresponding speed of motion of supporting textile.

In the next set of experiments the microstructure of the samples have been studied on SEM Tescan Maia 3. By the analysis of the obtained photos we found a number of important structural parameters: nanofibers and holes size distributions, their orientation. These results can be used to produce a numerical 3D model of the nanotextiles. The common model of a nanotextile structure consists of multiple 2D layers separated by certain distance [1]. Thus, it is important to determine the planar structure of each layer and the separation distance such that the resulting model serves as the best approximation to the real 3D structure.

In order to understand the internal structure of the material we have made blade cuts and studied the surface of the cuts by SEM. While we failed to get as detailed photos of the cuts as the planar structure, we were still able to determine the thickness of the cut and its basic structure. The cut looks almost exactly like the surface of the textile – a network of fibers with random orientations. We devised two different methods to determine the optimal set of parameters for the multilayered model, which give the best approximation to the observed structure of the material. The first method is based on measurement of thickness of the cut and analysis of the photos of the surface of the textile. The second method additionally takes into account the observed similarity of the cut structure to the planar one. The both methods produce close results.

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[1] Sambaer, W., Zatloukal, M. a Kimmer, D., Chem. Eng. Sci. 82, 299-311, 2012.