Master's Thesis Engineering Technology

Creating multilayered polymer nanocomposites using a static mixer

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Introduction

In the industry, it is very important to pack products adequately and to protect the product against various influences. Foils are often used in different types of sectors with different requirements. In order to improve the properties of a foil, particles can be added to the polymer or various layers with specific properties can be combined to a multilayer. Currently multilayered foils are widely produced using a complex stacking process which requires high temperatures leading to high energy consumption and high costs [1]. To overcome the above high energy process, this thesis focuses on creating particle-filled-multilayers using static mixers. It concentrates on the challenges related to the construction and optimization of static mixers that can produce 16 and 64 layer foils with and without particles.

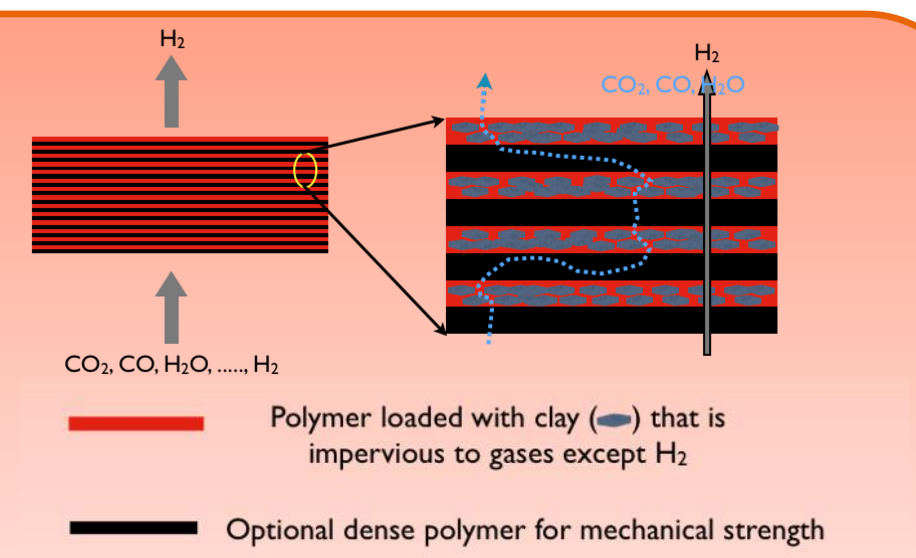

Figure 1: Diffusion path of a multilayer nanocomposite

Materials and methods

Working principal of a static mixer

- Test material will be:
  - Stretched
  - Cut
  - Stacked together

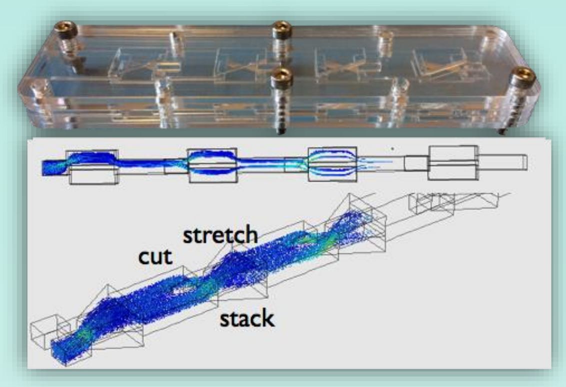

Figure 2: Flow of a material through the static mixer

Construction of the static mixer

- Needles, tubes, syringes, plates, screws

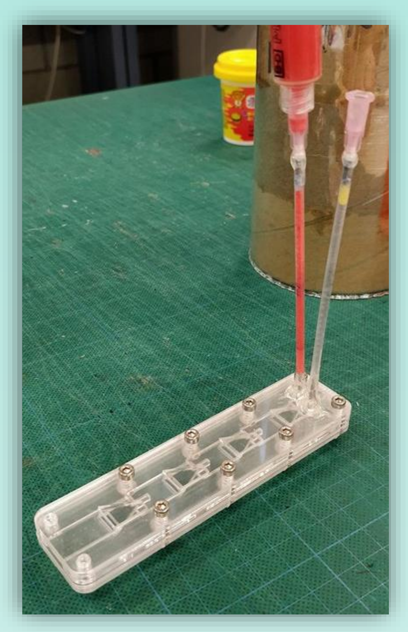

Figure 3: Static mixer setup

Development of a tripod

- For supporting the syringe with test material during injection

Figure 4: Tripod for mechanical tests

Tests

- Performed with tensile testing machine (MTS)
- Test materials:
  - Children's modeling clay
  - PEO and PEO+MMT - mixtures
  - Epofix mixtures with PS and MMT particles

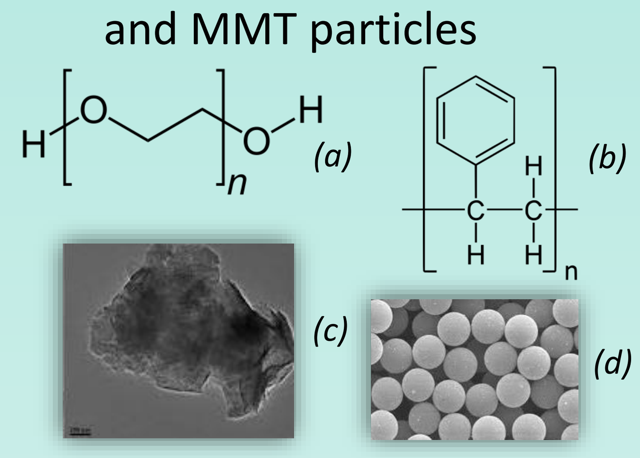

Figure 5: Chemical formula of (a) PEO and (b) PS; Microscopic view of (c) MMT and (d) PS

Results and discussion

Figure 6:Obtained output of 2 colored Darwi clay mixtures

Figure 6 shows the inner structure of the clay output. This figure shows clearly that there are multilayers layers. These layers are not uniform as the shear rate with the static mixer is not constant.

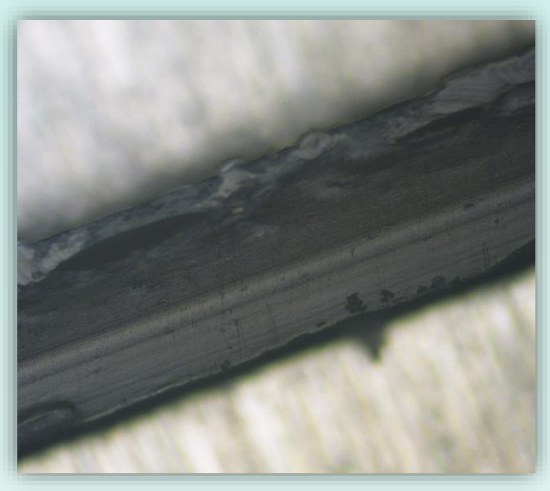

Figure 7: Obtained output of (PEO+MMT) -suspensions

Figure 7 shows the inner structure of the (PEO+MMT) output. On this figure different straight layers can be observed. Above these layers there is an area where no layers can be observed. Here the mixtures are probably mixed together.

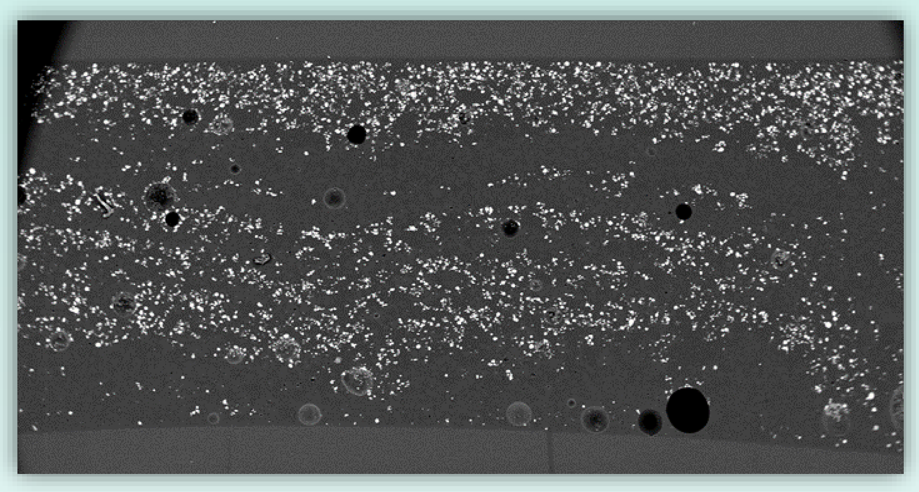

Figure 8: Output of Epofix mixtures with 6 µm PS particles and MMT particles

Figure 8 shows the inner structure of the Epofix output. On this figure, it can be seen that non-uniform layers have been formed. This may be due to the shear resistance that occurs against the wall of the static mixer in both mixtures.

Conclusion

- **Multilayers can be produced with static mixers**
- Viscosity has large influence → formation of uniform multilayers
  - Too low
    - Test materials mix with each other
    - Output sheet collapse

    } No layers formed/ observed
  - Too high
    - High pressure required → defects (leaks, burst)

- Shear resistance has influence → formation uniform multilayers
  - Test materials:
    - Against walls → shear resistance high
    - In the middle → shear resistance low

    } Different speed → non-uniform layers
  - During test
    - Changing rheological material properties
    - High pressure initially, than lower pressure
    - No slip at the walls

    } Non-uniform layers formed

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[1] C. Abeykoon, A. L. Kelly, E. C. Brown, J. Vera-Sorroche, P. D. Coates, E. Harkin-Jones, K. B. Howell, J. Deng, K. Li and M. Price, "Investigation of the process energy demand in polymer extrusion: A brief review and an experimental study," Elsevier, Bradford, Belfast UK, 2014.

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