Laboratory for Microscale Polymer Processing

Processing Micro Report #1

Batch extrusion of microtubing

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INTRODUCTION

Medical tubing based on polymeric materials is commonly used for various applications. Many problems, however, require the use of microtubing characterized by an OD (outer diameter) in the range of 0.5 to 2 mm, in combination with wall thicknesses of 50 to 200 µm. These tubes might be used in medicine and life science, for instance as stents, catheters, nerve guidance channels[1], micro fluid chip connectors, or in shape memory applications. There are many companies producing microtubing on a commercial scale; however in an experimental stage, only small amounts of a new polymeric materials are available for processing. Thus the extrusion of microtubing at a gram scale would be beneficial for many investigations.

EXPERIMENTAL

The polymer was extruded from a commercially available SWO Rheo Meltflixer, which is a combination of MFI and simplified capillary rheometer. The dimensions of cylinder and plunger comply with ISO 1133. The piston speed can be controlled at 0.1 mm/s and up. The custom-made tube die (OD: 2.3 mm, ID: 1.8 mm) is based on a design developed by Suter and Stoll [1, 2] for batch tube extrusion. Three temperature controllers monitor the upper and lower barrel as well as die temperature. A thermoplastic urethane elastomer (5g) was extruded at a temperature of 200°C and piston rates of 0.2 mm/s, resulting in a pressure of around 160 bar. The tube OD and ID can be adjusted by a draw-down imposed by a winding motor and/or by the pressure in the tube during extrusion. The SEM micrographs were obtained on a JEOL JSM 6400 using gold-sputtered samples.

RESULTS & DISCUSSION

The extrusion of the test material using the tube die renders microtubes of different ODs and wall thicknesses. Processing parameters are barrel and die temperature, extrusion rate, gas pressure during extrusion, and draw-down. Figure 1 shows the tubing as extruded.

Fig. 1: Extruded microtubing (2.7g) obtained with a draw-down of around one.

The optimal processing temperature was determined in preliminary experiments; a certain melt strength and viscosity of the polymer is required to prevent holes and tube rupture at the die exit. As shown in Table 1, a variety of tube dimensions can be realized by adjusting the processing parameters mentioned above. The overall amount of a new polymer needed should not fall below 5g, since the optimization of processing parameters for a certain OD/ID ratio requires first the determination of the optimal extrusion temperature and then several experiments to extrude sufficient amounts of a target OD/ID.

As seen in the SEM micrographs in Table 1, e.g. for sample 3, the wall thickness distribution is sometimes uneven. This is probably caused by the die design and more severe for higher melt viscosities and lower draw-downs. The use of pressurized gas in the tube during extrusion is not necessary for thick tubes, but is needed for the realization of thin tube walls.

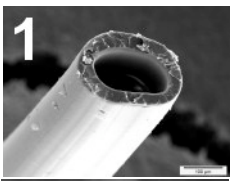
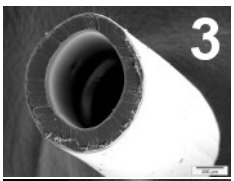
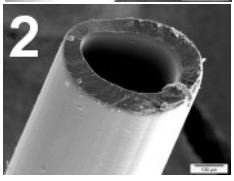
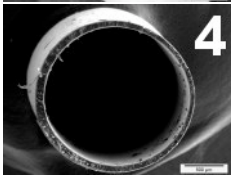
All dimensions in µm	Bar	OD	ID	Wall thickn.	Proc. cond.		Bar	OD	ID	wall thickn.	Proc. cond.
	100	180-270	110-200	35	high draw down		200	880-1030	580-730	150	no draw down
	100	330-490	200-340	65	some draw down		500	1950 - 2040	1770 - 1860	90	no draw down; pres–sure

Table 1: SEM micrographs of a selection of extruded microtubes. Tubes with small ODs (sample 1) are obtained by high draw-down rates, whereas a thin wall thickness (sample 4) is achieved by a higher nitrogen pressure in the tube during extrusion.

REFERENCES

[1] M. Borkenhagen, R.C. Stoll, P. Neuenschwander, U.W. Suter, P. Aebischer, *Biomaterials* **1998**, *19*, 2155
[2] R.C. Stoll: "Degradable, tubular DegraPol implants", PhD Thesis ETH Zürich, 1997.

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