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The invention and innovation of a novel plastic Microcapillary Film technology

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We have invented a simple and exciting plastic processing technique that can be retrofitted to existing polymer extrusion lines. The novel extrudate, Microcapillary Film (MCF), is a flat, flexible, plastic film containing an array of microcapillaries that run along its entire length. The precision-engineered capillaries can be tailored to be effectively uniform and can range between 3 microns and 3 millimetres in diameter depending on processing conditions and polymer choice; some examples of MCF cross-sections are shown in Figure 1.

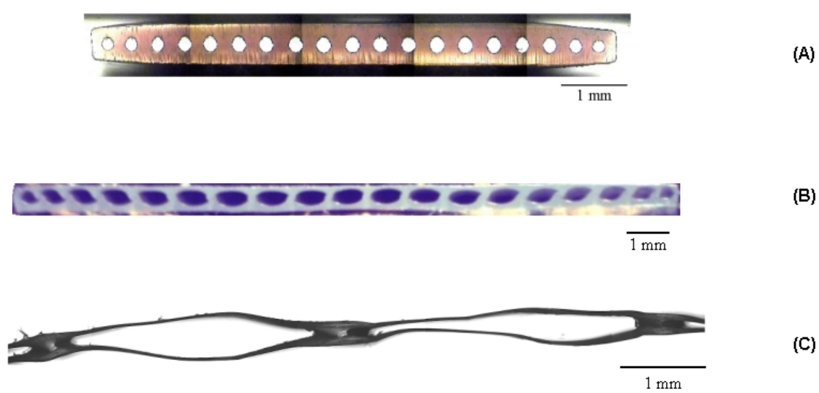
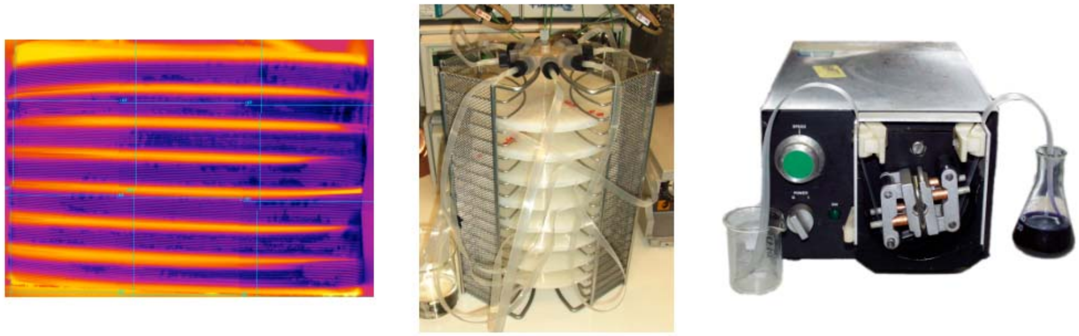


Figure 1. Photomicrographs of (A) standard voidage MCF (B) high voidage MCF and (C) ultra high voidage MCF. The polymer is linear low-density polyethylene (LLDPE).

The MCF process combines elements from fibre spinning, foam blowing and film casting processes. Process development has been ongoing since mid 2003; during this time we have applied for three patent applications [1-3] and have published academic papers and articles on the fabrication process and MCF material characterisation [4-10]. The process is currently at a pre-production stage, capable of producing kilometre lengths of high-precision MCF with capillary pitches accurate to within about 10 micron. This has been achieved through a series of incremental die designs coupled with fabrication improvements.

The inventors have been keen to both find application areas for MCFs and to find appropriate industrial partners to continue joint application development. Extensive research has been carried out using MCFs as low-cost plastic heat exchangers [6, 10], as low-cost, disposable, chemical microreactors for pharmaceutical and fine chemical synthesis [7], as a functional component in pressure sensing devices and as a peristaltic pump membrane. Figure 2 illustrates some of these applications.



(A) (B) (C)

Figure 2. (A) Thermal image of a prototype MCF heat exchanger in operation, (B) a stack of 8 microcapillary flow-disk microreactors for organic synthesis and (C) using an elastic MCF in a peristaltic pump for parallel micro metering.

We have been successful in securing a manufacturing licence for fluoropolymer MCFs with a UK SME aimed at producing material for the microreactor sector. In addition we are working with two additional UK SMEs and an America's Cup racing team to test out the use of high voidage MCF as an essential component in a device to measure pressure profiles across sails whilst in use. In addition, the inventors are in dialogue with a number of additional UK-based companies in sectors such as peristaltic pumping and heat exchange with the aim of commercialising other areas within which MCF technology could bring benefits. Based on market research carried out by an external consultancy, we are currently considering the merits of forming a company to exploit the benefits of MCFs.

Recent developments in MCF processing have reduced the capillary diameters to 3 micron. We are now close to being able to realise capillary formation in the sub-micron regime. Continuous fabrication of MCFs at these length scales would yield coloured fibre-like extrudates with colouration due to diffraction effects rather than chemical dyes. Moreover, these micro-extrusion techniques may also allow continuous production of functional nano-structured materials such as photonic fibres.

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