**ABSTRACT**

# Glucose diffusivity of electrospun polycaprolactone (PCL) scaffolds for tissue engineering bioreactor

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The effects of electrospinning duration, polymer flow rate and viscosity on pore morphology of polycaprolactone (PCL) scaffolds are investigated. The glucose diffusivities of both commercial and in-house fabricated scaffolds imbibed in cell culture medium (CCM) with and without the presence of cells are then measured. It is observed that the electrospinning process is reproducible and fiber-fiber space and fiber diameter are both increased with higher PCL flow rate. Furthermore, glucose diffusivity is reduced in the presence of cells.

**INTRODUCTION**

Electrospinning is an efficient way to fabricate scaffolds for tissue engineering purposes. Cell seeding optimization in polymer scaffolds is also essential for *in vitro* cultivation of functional tissue constructs. The role of polymer (PCL) flow rate, experimental duration and viscosity on the production of different pore morphology of electrospun scaffolds are investigated. Importantly, the glucose diffusivities in these scaffolds are determined with a view to relate the scaffold morphology to glucose diffusivity. The results of this work will provide improved tool for designing and modeling nutrient transport in tissue engineering bioreactors with electrospun scaffolds.

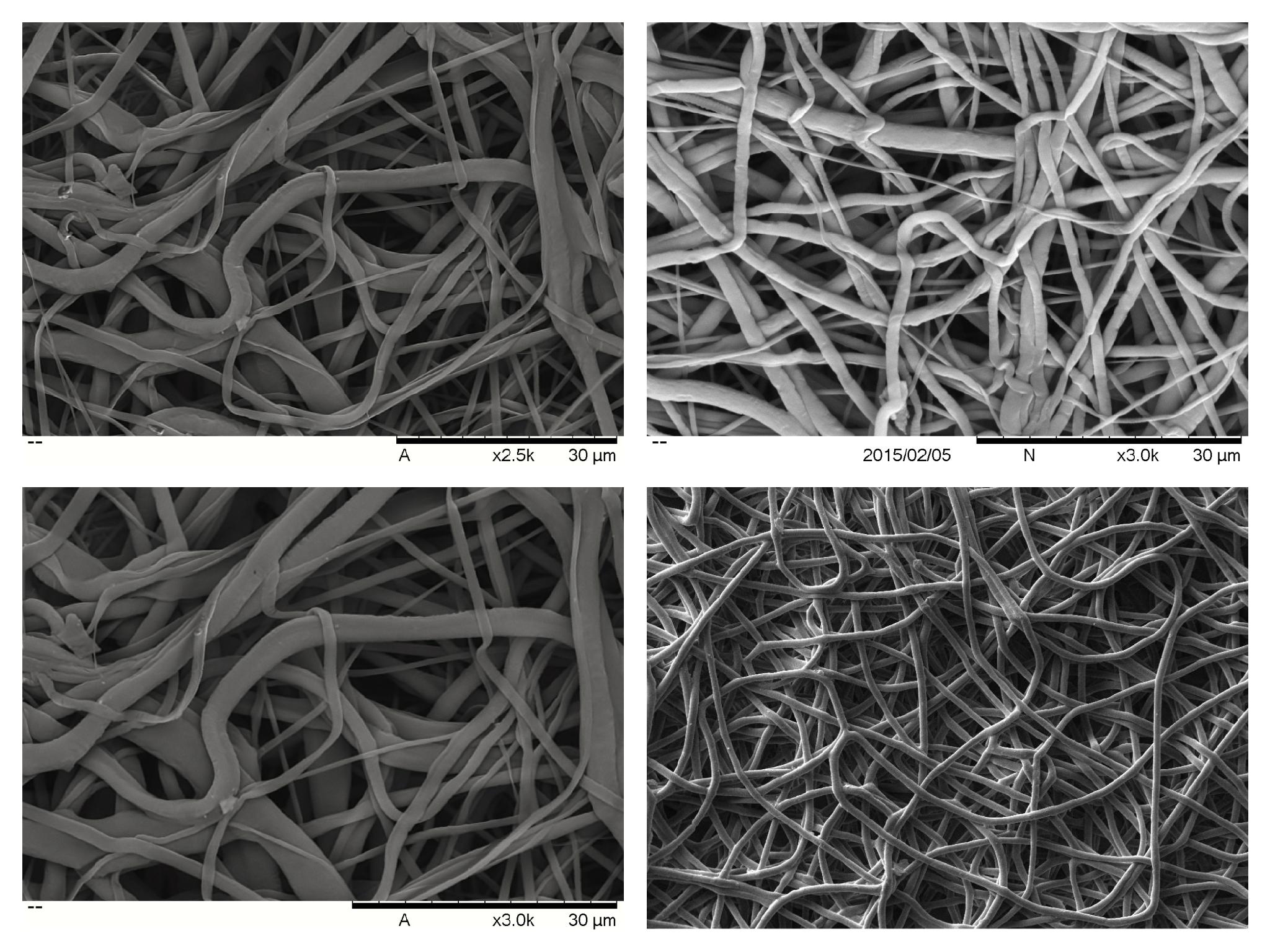
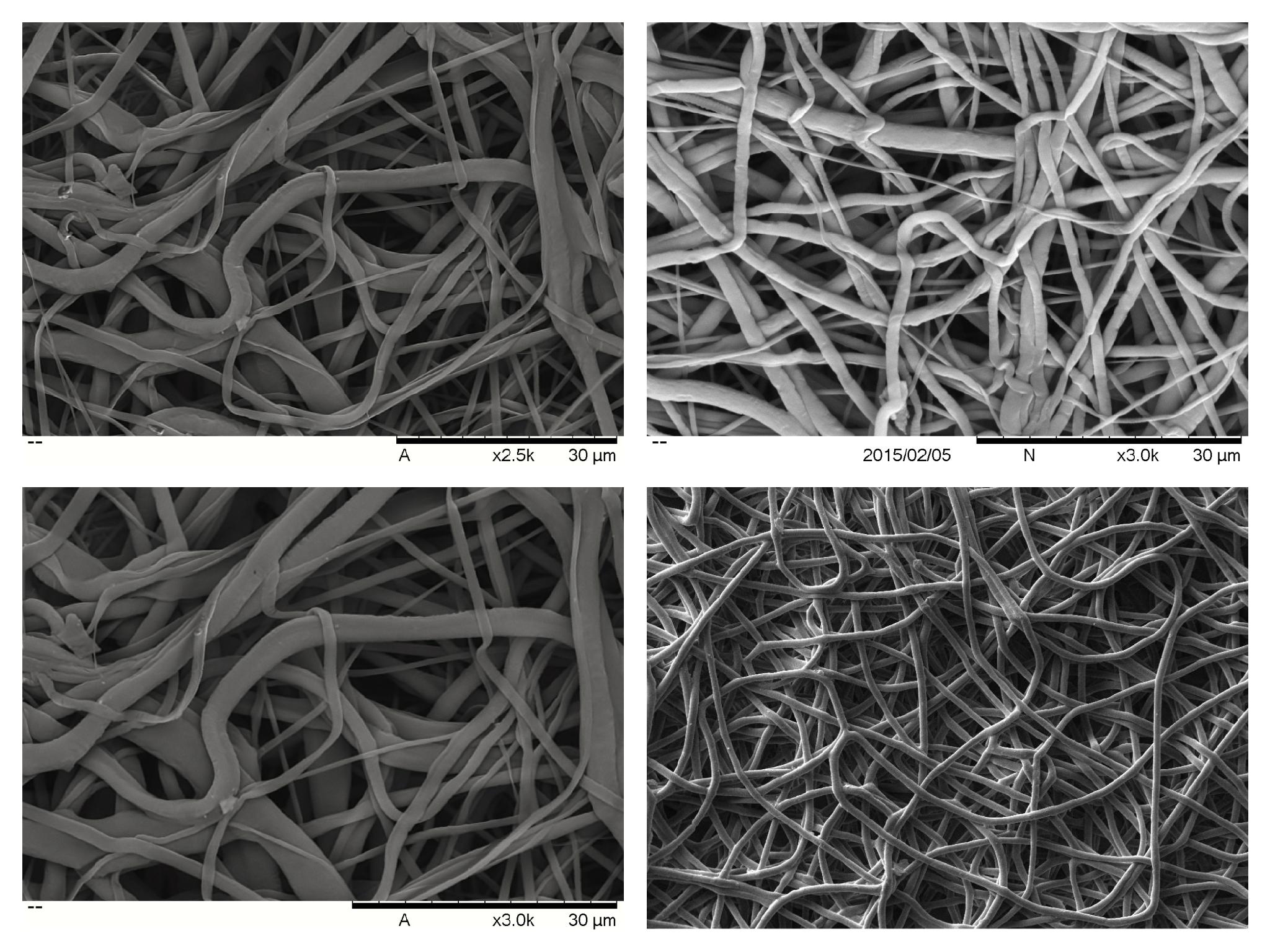
### **Materials and Methods**

1) *Materials*: Polycaprolactone (PCL) pellets (MW=80,000), dichloromethane solution (DCM) and N,N-dimethylformamide (DMF) were purchased from Sigma-Aldrich. The solute used was of D-glucose-anhydrous (Fisher Scientific UK Ltd, UK). Also, commercial PCL scaffold was purchased from the Electrospinning Company Ltd. (Didcot, UK). The cell culture medium (CCM) used was Dulbecco’s Modified Eagle Medium (DMEM) (Life Technologies Ltd, UK).

2) *Fabrication for PCL scaffolds:* Firstly, PCL (12 wt %) was dissolved in DCM and DMF (3:1 v/v) solvent. The solution was mixed at 600 rpm for 2 hr at room temperature (25±1°C). The PCL solution was placed in either one or two 3 mL plastic syringes. A voltage of 15 kV, a feed flow rate of 1 or 2 mL/h and a distance of 12 cm between needle tip and collector were maintained. The experiment was carried out at a humidity of 45%. The duration of experiment was 1.5 h (one syringe) or 45mins (two syringes)*.*

3) *Glucose diffusion experiment*: A diffusion cell was built to determine the glucose diffusivities in CCM [1]. Briefly, the cell consisted of two half chambers, namely, the donor and receptor chambers. The scaffold was fixed in between these chambers. Samples were taken at an hourly interval from both the chambers until mass transfer equilibrium was achieved. Glucose concentration was determined by an YSI glucose analyser (YSI 2300 STAT PLUS, YSI UK Ltd).

**RESULTS AND Discussion**



c

d

b

a

Figure 1 SEM images of: (a) 1 ml/h, 90 min with 1 syringe (b) 2 ml/h, 90 min with 1 syringe (c) 1 ml/h, 45 min with 2 syringes and (d) Commercial PCL scaffold

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| --- | --- | --- | --- | --- |
| Electrospinning parameters  Flow rate, number of syringe, experimental duration | Average Fiber-fiber space (μm) | Average fiber diameter (μm) | Diffusivities in CCM1011(m2/s) | |
| With cells | Without cells |
| 1 ml/h,1,90mins | 1.38 ±0.756 | 0.78±0.409 | TBC | 2.84±0.12 |
| 1 ml/h,1,90mins | 1.43 ±0.532 | 0.88±0.179 | TBC | 2 .95±0.52 |
| 1 ml/h,1,90mins | 1.58 ±0.362 | 0.78±0.256 | TBC | 2.71±0.35 |
| 2 ml/h,1,90mins | 3.80±1.695 | 2.10±0.765 | TBC | 3.75±0.71 |
| 1 ml/h,2,45mins | 1.88±0.770 | 0.91±0.641 | TBC | 3.22±0.13 |
| Commercial | 20-30 | TBC | 1.32±0.10 | 17.8±5 |

Table1 The electrospun scaffolds and glucose diffusivities with/ without cells

The repetition of the same experimental condition produces similar results in terms of fiber-fiber space and fiber diameter, which means the scaffold fabricated by electrospinning is reliable and repeatable. In Table 1, it has been shown that increasing flow rate causes increased fiber-fiber distance and fiber diameter, which may be due to insufficient solvent evaporation. It is also evident from Table 1 that the usages of two syringes and by having the experimental duration, the fiber-fiber space and fiber diameter have slightly increased. Bigger radius with two syringes causes a larger coated area. Hence, the electrospinning with two syringes is more efficient. Compared with the cell free scaffold, glucose diffusivity with seeded cell scaffold is reduced, due to narrower channel for passing through.

**CONCLUSIONS**

In this study, the effect of electrospinning parameters, such as the polymer flow rate and electrospinning duration on pore morphology of electrospun PCL scaffolds are investigated. Higher flow rate increases fiber-fiber space and fiber diameter with wider distribution due to the insufficient solvent evaporation and gravitational force. The fiber-fiber distance and fiber diameter are also slightly increased with the usage of two syringes. Effects of these precense of cells on glucose diffusivity is being determined.

**REFERENCES**

[1] H. Suhaimi, S. Wang, T. Thornton, D.B. Das, On glucose diffusivity of tissue engineering membranes and scaffolds, Chem. Eng. Sci. 126 (2015) 244–256.