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THE EFFECT OF FLUID VELOCITY ON THE DIFFUSION OF TRIMETHYLENE GLYCOL THROUGH A REVERSE OSMOSIS MEMBRANE IN MICROCHANNEL -X

Sugeng Hadi Susilo[1], Zahratul Jannah[2], R.N. Akhsanu Takwim[3]

1,2,3) Department of Mechanical Engineering, State Polytechnic of Malang, Jl. Soekarno-Hatta 9 Malang-indonesia.

Correponding email [1)] :
sugeng.hadi@polinema.ac.id

Abstract. The study aims to observe the diffusion process which is influenced by different velocity and fluid concentrations. Using a microfluidic system and the diffusion process through a reverse osmosis membrane. The research was carried out by flowing fluid into the microchannel. The diffusion process is known by measuring and analyzing the density of liquid waste aquades-trimethylene glycol. The results showed the amount of diffusion through the membrane was influenced by flow velocity and fluid concentration. this is because the velocity of the flow produces pressure on the wall so that it pushes the fluid to diffuse through the membrane.

Keywords : Diffusion, velocity, concentration, microchannel.

1. INTRODUCTION

The microchannel is one of the new technologies in the pharmaceutical field. In the pharmaceutical field, the microchannel is assumed to be a blood vessel of a living thing [1]–[3]. Fluid flow in the microchannel allows dynamic changes to occur at certain times and conditions. Diabetes mellitus is a disease related to blood plasma. Increased viscosity of blood plasma causes diabetes [4], [5]. The viscosity of human blood that is higher than the normal limit will have a negative effect. One negative effect is the heart's performance to pump blood heavier and can damage the walls of blood vessels [6]–[8].

The two channels on the microchannel that are insulated with a membrane represent external and internal fluids in human cells. Diffusion that occurs through a porous membrane describes the process of absorption of nutrients or drugs that enter the body through the blood [9].

The advantages of using microchannel in pharmaceutical research include, lower costs because the tool can be used repeatedly, accurate results because the channel model used is representative of metabolic and circulatory organs in the human body, and easier in terms of observation because the microchannel comes from materials transparent rather than having to do surgery on human organs, including testing for antibiotics or other drugs that enter the metabolism of living things [10], [11]. Fluid flow in the microchannel allows for differences in concentration at the meeting point of the fluid caused by the diffusion process and easier observation [12], [13].

Also, research at the micro-scale when compared with studies at the macro scale has a very different surface volume ratio, has buoyancy force, inertia force and forces on the surface such as adhesion and surface tension. Characteristics of flow in the microchannel are fluid flows considered laminar, Reynold numbers are low and there is molecular diffusion associated with diffusion between reagents [14].

The Microchannel applications include mixer, microreactor, and cytotoxity. This is related to chemical reactions at a micro-scale that is faster with a small volume and a short diffusion process to allow faster fluid mixing.

The microchannel as cytotoxicity screen, in which the core flow is enveloped by liquid fluid sheaths [15], [16]. The use of cytotoxicity as a way to send samples of cells covered with liquid fluid to the core flow area. The form of flow cytotoxicity is adopted from the form of laminar flow and diffusion Mixing of fluids in the interphase region is entirely affected by diffusion.

The microchannel used in biotechnology for vesicle liposome generation [17]–[19]. A liposome is a nanoparticle that is in phospholipid fluid, plays a role in biotechnology and as a drug or genetic material in cells. The character of laminar flow microfluidics is caused by, among others: low temperature, shear stress and composition fluctuations in the reaction causing the product to have high mono dispersion compared to most liposome production [20]. The size of the vesicles is one of the factors that determine the amount of liposome material. The microchannel used in the field of rheology with polymeric materials [2]. The results showed that changes in the flow of liquid polymer particles in the core channel are affected by shear forces and elasticity.

The human digestive system involves several organs and works very complex. Food and medicine that enters the body will be digested into energy, nutrients and produce the remaining processes which must then be removed from the body [21], [22]. The process begins with the destruction or conversion of large molecules into small ones so that they are easily absorbed by the body. The absorption of nutrients from the gastrointestinal tract into cells is divided into several mechanisms, namely passive absorption, convective transfer, active absorption, facilitative transport, ion-pairing and pinocytosis [23], [24]. Some nutrients and drugs are absorbed in the small intestine through the surface of the large mucous villi. Gastrointestinal membranes consist of lipids and proteins so that fat-soluble drugs quickly penetrate the gastrointestinal membrane. While the cell membrane is not too much different, which consists of fat, phospholipids, cholesterol, enzymes and so on to enable the transfer of substances either actively or passively [12], [25].

Passive diffusion in the membrane consists of two mechanisms, namely through the carrier protein and channel protein. Channel proteins have holes or pores for the process of diffusion of substances from the digestive tract into body cells, but not all substances in the digestive tract can penetrate the membrane through this mechanism [16], [26], [27]. Ions that cannot penetrate through the mechanism will be assisted by ionophore, usually synthesized by microorganisms. Small, polar and uncharged molecules such as glycerol can diffuse into cells through membranes, while large, polar and uncharged molecules such as glucose and sucrose can partially enter through the membrane and some cannot. The membrane used in the experiment is a reverse osmosis membrane which generally has a membrane pore size of around 40 µm, a thickness of 120-150 µm and there is a barrier layer of layers on the surface which has a thickness of 0.2 µm. But based on experiments, the size of the membrane pore radius used in the experiment was 1.095 µm.

2. METHODS

The research work is intended to investigate the parameters of the trimethylene glycol diffusion process on Microchannel -X by experiment. This report is written with a variety of velocity a stream against its diffusion process. So that the process of trimethylene glycol diffusion process can be identified in the form of a product concentration waste.

The X-microchannel consists of the top and bottom parts, as shown in Figure 1. The red line shows the channel for Trimethylene glycol (top) flow, while the blue line shows the channel for the flow of distilled water (bottom). The pink line shows the diffusion process. The bulkhead uses a membrane with a radius of 1.0943 µm.

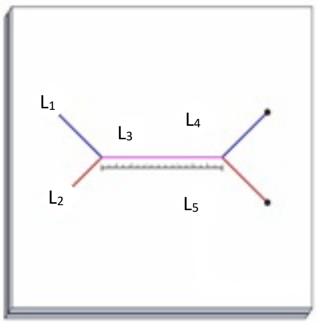

Figure 1. Microchannel type-X

The Microchannel is rectangular with a side of 200 µm, with a channel length of 1000 µm. The length of the inlet and outlet of the microchannel used in this study were L1, L2, L4, L5 = 500 um, L3 = 1000 um with the width of 200 um, and the depth of 200 um, as shown in Figure 1. The arrangement of microchannel material in size (10x10) cm with a thickness on 5 mm arranged accumulated.

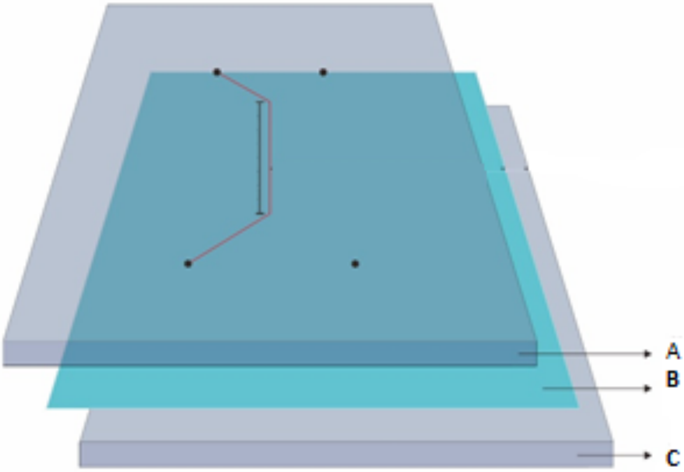

Figure 2. Microchannel Parts, A. Top Cross-section Microchannel; B. Porous Membranes; C. Lower Acrylic Section.

The two microchannel sections are joined together in the same arrangement as in Figure 2. Then the inlet section is connected to the TS-1B / W0109-1B syringe pump type and the outlet part is connected to the reservoir [28], as shown in Figure 3.

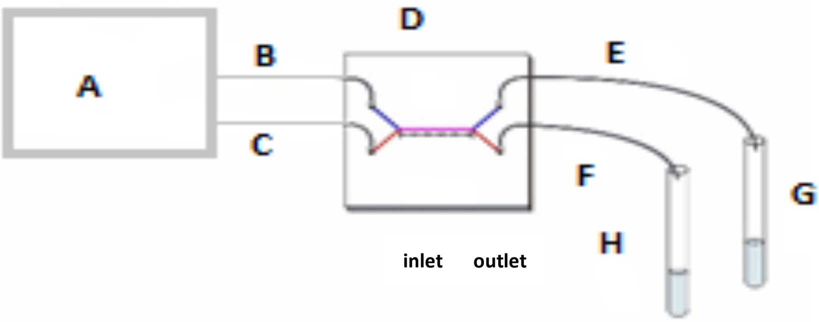

Figure 3. Experimental setup A. Sprynge pump, B. Aquades injection hose; C. Trimethylene glycol injection hose; D. Microchannel; E. Waste Aquades-Trimethylene glycol Mixed Waste Hose; F. Waste Trimethylene glycol Hose; G. waste 1; H. waste 2.

The research was performed with the velocity stream variations of 50 um/s, 100 um/s, 150 um/s and 200 um/s, and with a concentration of 0.1M; 0.25M; 0.5M; 0.75M; 1M. Syringe pumps were used to flow the fluid from the two inlets, as shown in figure 3.

3. RESULTS AND DISCUSSION

This research was conducted to determine the effect of flow velocity and concentration on the diffusion of Trimethylene glycol through a reverse osmosis membrane in a microchannel. The concentration of Trimethylene glycol which diffuses through the membrane can be determined by measuring the density of the mixture of Trimethylene glycol and distilled water outlet channels.

3.1 EFFECT OF VELOCITY ON DIFFUSION

Based on the density measurement data on the mixture of Trimethylene glycol and aquades, the magnitude of the diffusion of Trimethylene glycol through the reverse osmosis membrane is shown in Figure 4.

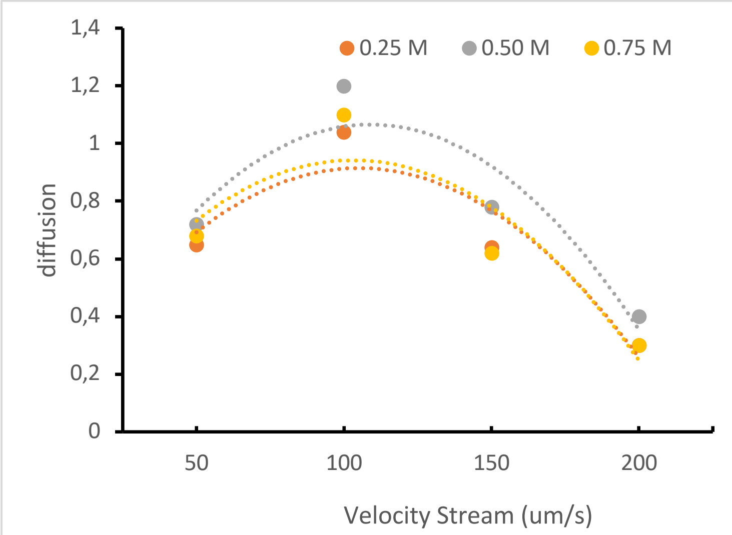

Figure 4. Relationship of Diffusion to Flow Velocity

Figure 4 presents the diffusion profile of Trimethylene glycol, showing that there are differences in the magnitude of diffusion at a different velocity. The amount of diffusion increases at a velocity of 100 um / s, then decreases with the increasing flow velocity. This happens at various concentrations. The biggest diffusion occurs at a flow rate of 100 um / s with a concentration of 0.50 M.

The amount of diffusion is strongly influenced by the pressure which is the driving force to pass through the porous membrane. The amount of pressure is affected by the flow velocity and density of the fluid. The concentration of the liquid is certainly related to density, and which easily enters the membrane between 0.1-0.50 M. At flow rates above 100um / s, diffusion seems to decrease. The faster the flow, the smaller the chance of Trimethylene glycol compounds entering the membrane. This is influenced by the Trimethylene glycol molecule in the boundary layer being driven by the flow rate toward the outlet. Resulting in a compound that diffuses decreasing.

3.2 EFFECTS OF CONCENTRATION ON DIFFUSION

Based on the measurement data of trimethylene glycol concentration (M) on diffusion through the reverse osmosis membrane is shown in figure 5.

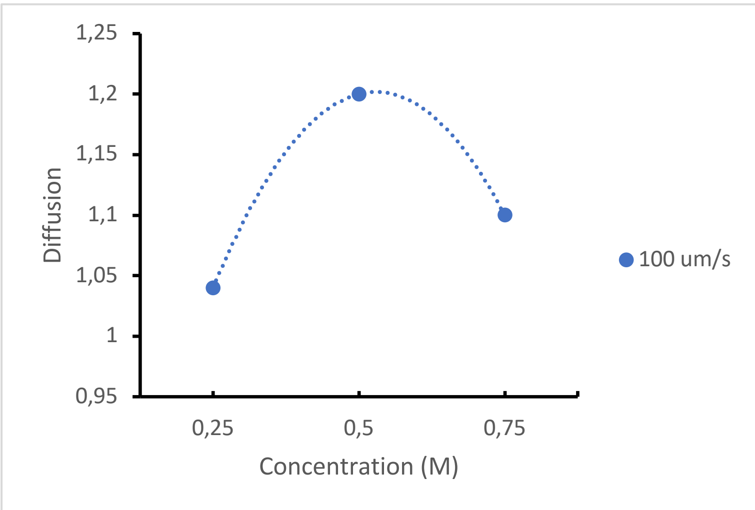

Figure 5. Relationship of concentration to diffusion at a velocity of 100 um / s.

Figure 5 shows the different magnitudes of diffusion in the microchannel channel at different concentrations. dilution of the concentration of the compound Trimethylene glycol tries to mimic the viscosity of human blood under normal conditions, anemia, and diabetics. There is a trend of a line that rises significantly and then decreases significantly with greater concentration. The difference in concentration shows that there is a relationship between the concentration and diffusion that occurs through the membrane. While the concentration is related to viscosity. When fluid flows near the membrane wall, friction occurs between the fluid and the wall

surface. This results in different flow rates. The greater the viscosity, the lower the flow velocity. The lower flow velocity causes the pressure on the membrane to decrease. Based on Figure 5 shows that at a concentration of 0.5 M a maximum diffusion is achieved at a flow velocity of 100 µm / s. Furthermore, with increasing fluid concentration, the number of diffusion decreases.
The use of aquades as a representation of cell fluids and Trimethylene glycol as cell external fluids both have different concentrations. at greater concentrations, fluid motion is slower due to the frictional force of the solution against the channel wall. The movement of fluid to diffuse will be smaller.

4. CONCLUSION

It was concluded that the amount of diffusion in the membrane is influenced by the velocity of the flow and density of the fluid. Flow velocity results in pressure on the wall thereby pushing fluid through the membrane. The concentration of Trimethylene glycol that easily enters the membrane is 0.50 M with a flow rate of 100 um/s.

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