CHAPTER II

2. FABRICATION OF THE OPTICAL MICROVISCOMETER BY CONVENTIONAL MICROMACHINING AND 3D PRINTING

Microfluidics requires design parameters to be in the order of microns and one of the easiest routes for realizing components at that scale was a well-known CNC (Computer Numerical Control) router for micromachining. The material and tool size limitation in micromachining made it difficult to realize a device made of acrylic and in the size order of 50 microns. The initial idea was to get it done using the carving machines in the interior design plants but then it became increasingly difficult as the usage of a particularly small sized tool was needed. This process also hampered the manufacturing of other products which made it more difficult. This made other routes of fabrication to be explored rigorously. One such method was to use the machine and the micron sized tool of a local badge manufacturer near the Indian Military Academy of Dehradun. The results
obtained were accurate to the scale of few hundreds of microns as shown in the figure 2.1.

![Micromachined Design on an Acrylic Sheet](image)

**Figure 2.1 Micromachined Design on an Acrylic Sheet**

For the above shown design, the micromachining was to be done on one plate and a second plate needed to be bonded to the first for a leak-proof device. But during the bonding and sealing process which is done manually, either the alignment failed or the positioning of the sheet shifted. Besides, the bond was not strong enough to stop the leakage of fluid into the sides of the actual channel thereby hampering the measurement as shown in the figure 2.2.
However, in microfluidics the most important parameter is the size followed by the steady flow of the fluid in the channel. In order to make the fluid flow in micro-channels, it is an absolute necessity to supply a pressure differential. These parameters caused problems while performing the experiments. With the advent of rapid prototyping combined with the limitless possibilities of 3D printing, the problems associated with the micromachining could be resolved. The applications of rapid manufacturing technology is useful for various functions ranging from biological studies to various aspects of energy, electronics, chemistry and life sciences.

3D printing encompasses a wide spectrum of techniques, some of which are even being used in industries. But for microfluidics, one particular technique namely ‘stereolithography’ (SLA) is the one that is extensively used [38]. This is because some of the SLA based printers can go up to a resolution of 56 microns like the MiiCraft 3D printer. This method provides us with the flexibility of printing complex three dimensional structures using polymeric materials [39]. The major hurdle of using external pumps and pumping equipment was solved by Begolo and his team by 3D printing the disposable parts (pumping lid and cup) of the
pumping mechanism in a microfluidic system and placing them before the channel inlet to send in the fluid by pressing the lid for pressure [40].

Many components pertaining to microfluidics like optical and electronic devices (base design), valves, mixers and even infusion pumps can be fabricated using the rapid prototyping techniques like laser ablation, PDMS casting, nanoimprinting and 3D printing [41]. The device printed by such quick processing methods are often called in as disposable devices, reason being that they take very less time to be fabricated combined with low cost material and fabrication technique [42]. Microfluidics being an area where the sample volume requirement is very less combined with the small size of the integrated system and the lesser time need for measurement enabling it to be the most preferred analysis and diagnostic technique in the biomedical world. Complex features and integration of such features is the real challenge in microfluidics [43-45]. Many research groups work on the 3D model designing of complex features involving membranes and varying channel sizes which can enable the study of drug transport to the diseased cells [46]. Such micro-total-analysis systems can at a single time carry out parallel processing of many tasks to churn out the required outputs [47].
The 3D printer used in this research to print the optical microviscometer was MiiCraft Kit (PN#95.LF800G004) from the Rays Optics, Taiwan shown in the figure 2.3. This is a stereo-lithography (SLA) based printing machine with a minimum resolution of 56 microns across the XY axis and 50 microns across the Z axis. It uses the bottom-up approach of printing based on UV resin curing technique [48].

![MiiCraft 3D Printer Kit](image)

**Figure 2.3 MiiCraft 3D Printer Kit**

The output file from the design software should essentially be saved in the STL format for the MiiCraft STL Viewer to position the design on the platform of the printer. This is followed by the Slicer program which slices the entire design into

![Optofluidic Microviscometer](image)

**Figure 2.4 Optofluidic Microviscometer (a) Design 1 (b) Design 2**
50 micron individual slices and generates the final index file for printing in the ‘Print STL Model’ module. The printer usually takes less than 5 minutes to print a model of height 1 mm using a standard available UV curable polymer input material. And after the printing it usually goes into a 5 minute post-curing cycle for the final product as shown in the figure 2.4 (a) and (b). The input material used in a transparent resin (MA-YG2005T) supplied by the company. It is a transparent liquid having a flash point of 150°C and a specific gravity of 1 gm/ml at 25°C.