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DEPARTMENT OF CHEMICAL ENGINEERING

FABRICATION OF COMPLEX MICROCHANNELS IN PDMS

# HELICAL CHANNEL

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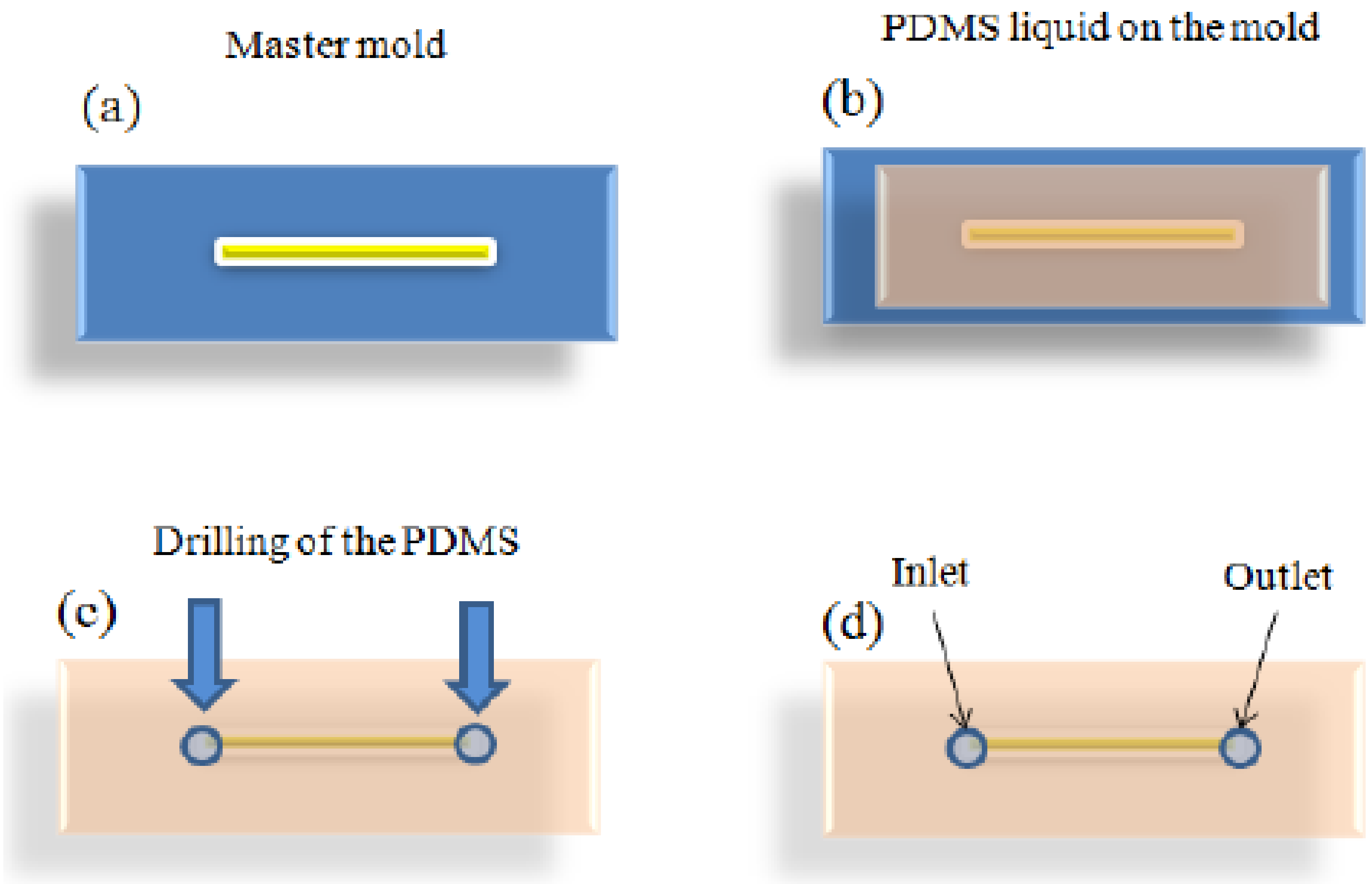
# INTRODUCTION TO MICROFLUIDIC SYSTEMS

1. **Definition**: Microfluidic systems involve the manipulation of fluids at a sub-millimeter scale.
2. **Key Components**: Channels, pumps, and valves designed to handle small volumes of fluids.
3. **Applications**: Used in diagnostics, chemical synthesis, drug delivery, and environmental monitoring.



# IMPORTANCE OF HELICAL CHANNELS

- **Helical Design:** Helical channels are spiral-shaped pathways that enhance fluid dynamics.
- **Benefits:**
- **Improved Mixing:** The helical shape promotes efficient mixing of fluids.
- **Increased Surface Area:** Maximizes interaction between fluids and surfaces.
- **Efficient Heat and Mass Transfer:** Enhances reaction efficiency in chemical processes.

## PDMS AS A MATERIAL

- **PDMS (Polydimethylsiloxane):** A versatile, silicone-based organic polymer.
- Properties:
- **Biocompatibility:** Safe for biological applications.
- **Flexibility:** Easily molded into complex shapes, including helical channels.
- **Optical Transparency:** Ideal for optical detection methods.
- **Gas Permeability:** Useful for cell culture and other biological processes.

# FABRICATION OF HELICAL CHANNELS IN PDMS

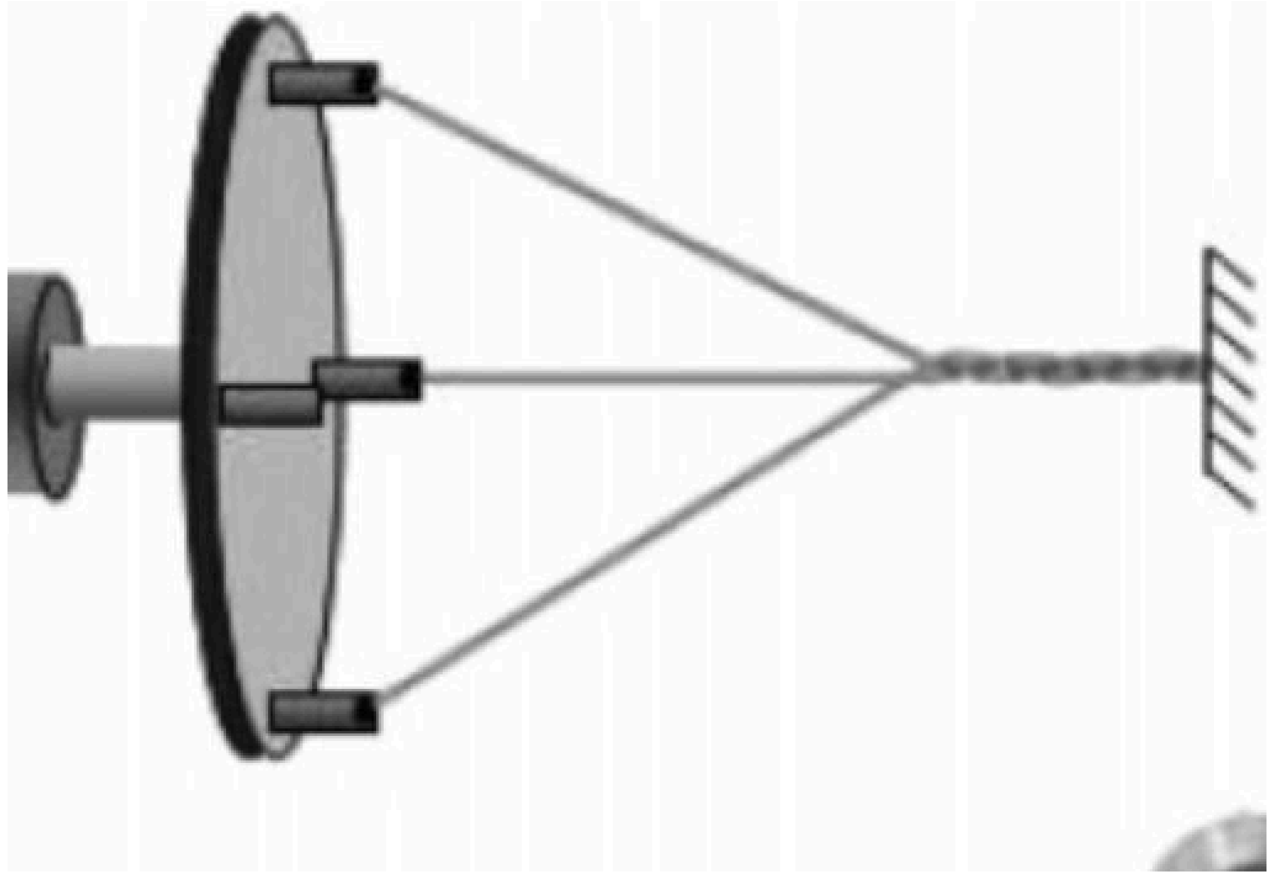
**Fabrication Process:**

- Step 1: Design the helical channel using OnShape software.
- Step 2: Create a master mold using photolithography or 3D printing.
- Step 3: Cast PDMS onto the master mold to form the microfluidic channels.
- Step 4: Cure and peel off the PDMS to reveal the helical structure.
- Step 5: Bond the PDMS to a glass or PDMS substrate to seal the channels.

# PROCESS

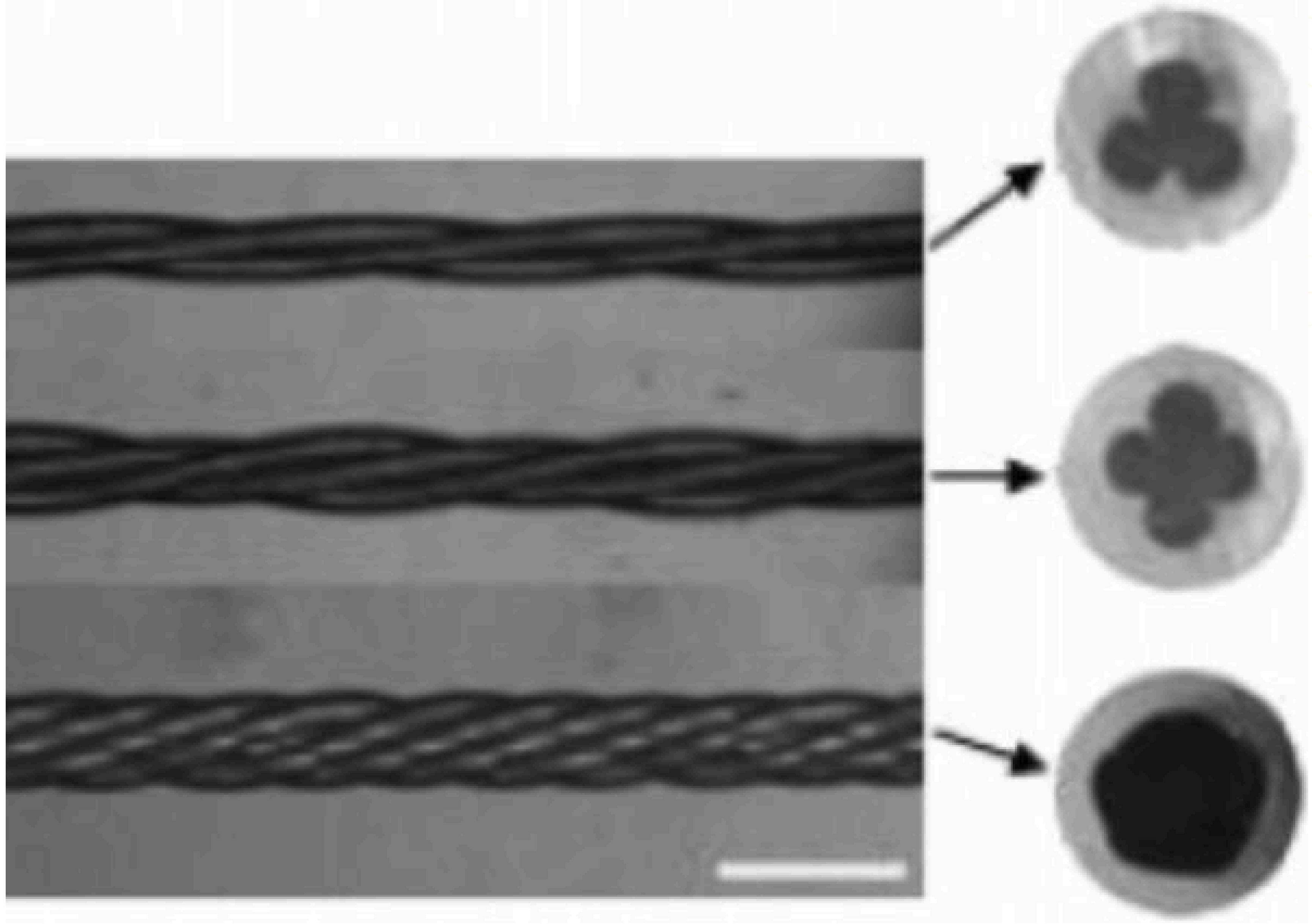
This combined translational and rotational sliding of the thread preserved the 3-D structure of the template in the channels

Channels with a large helix angle ((θ ) =70-80°), low pitch =0.4-0.5 mm ,large radius (r ) 400-500 μm, and long length=15-20mm

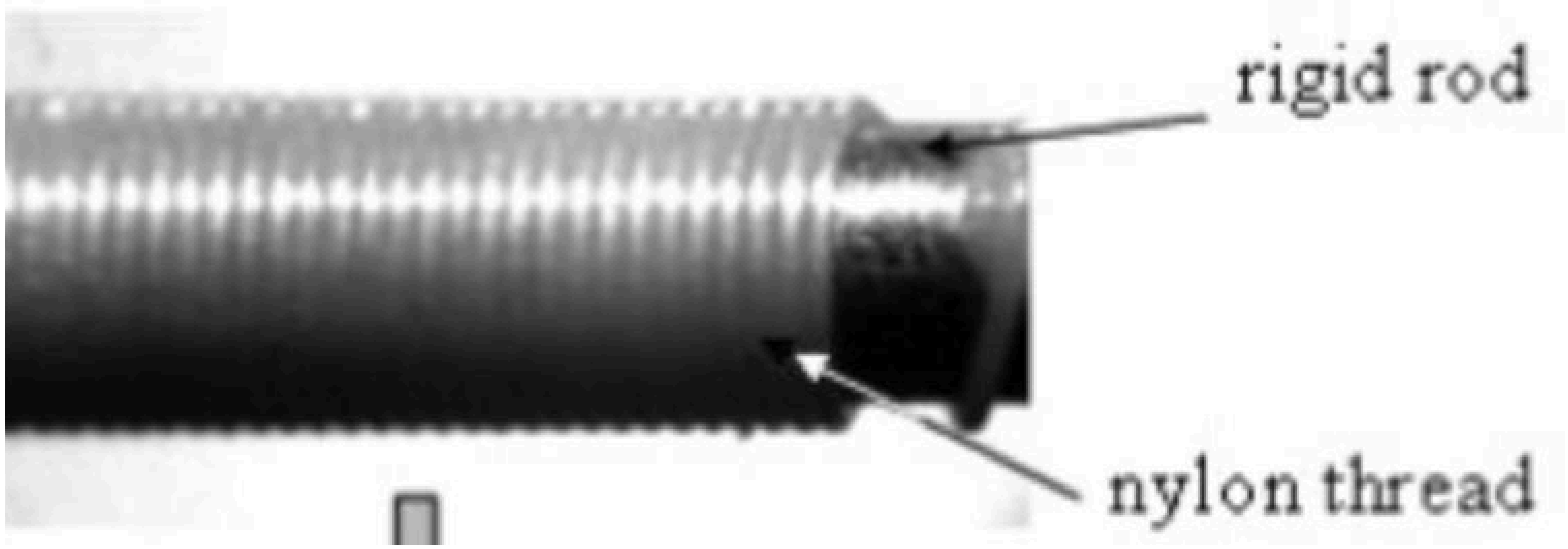


1.Channels generated using braids made of three and four strands, respectively. The magnified images of their cross-sections show the corresponding braided structure with -three to four lobes, the orientation of which rotates with a pitch along the length of the channe

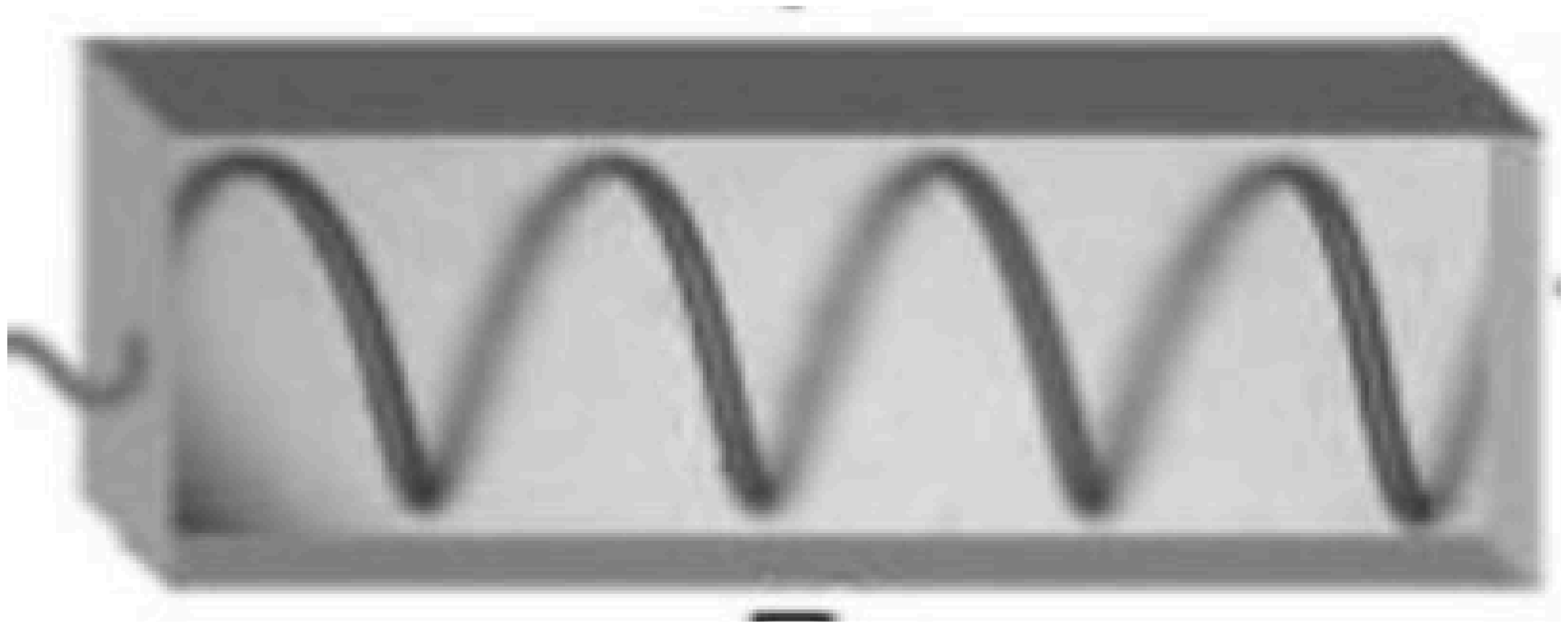
2.Central thread that remains stationary and five other threads, which revolve around it. As a result, here the cross-section of the microchannel attains the shape of a pentagon.



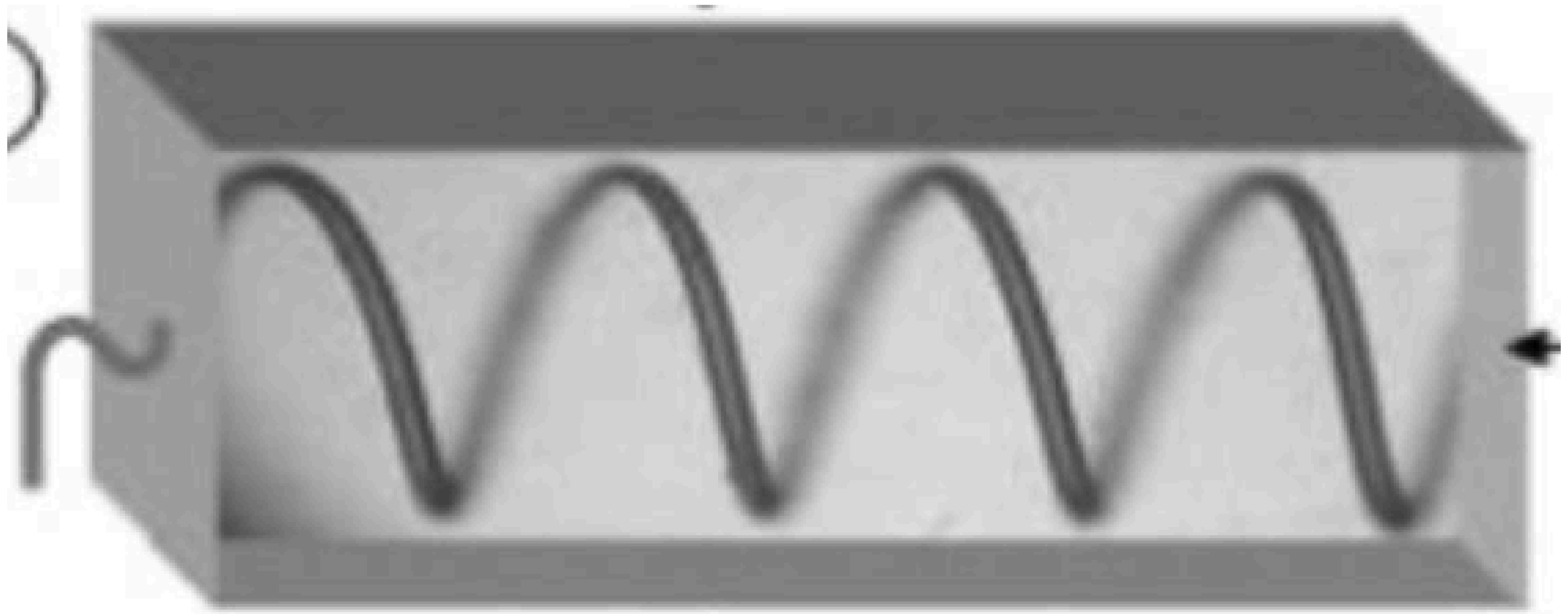
A). A straight piece of nylon thread was spun around a rigid rod at a desired pitch and was hot set at 100 °C



B). Nylon thread embedded in PDMF.

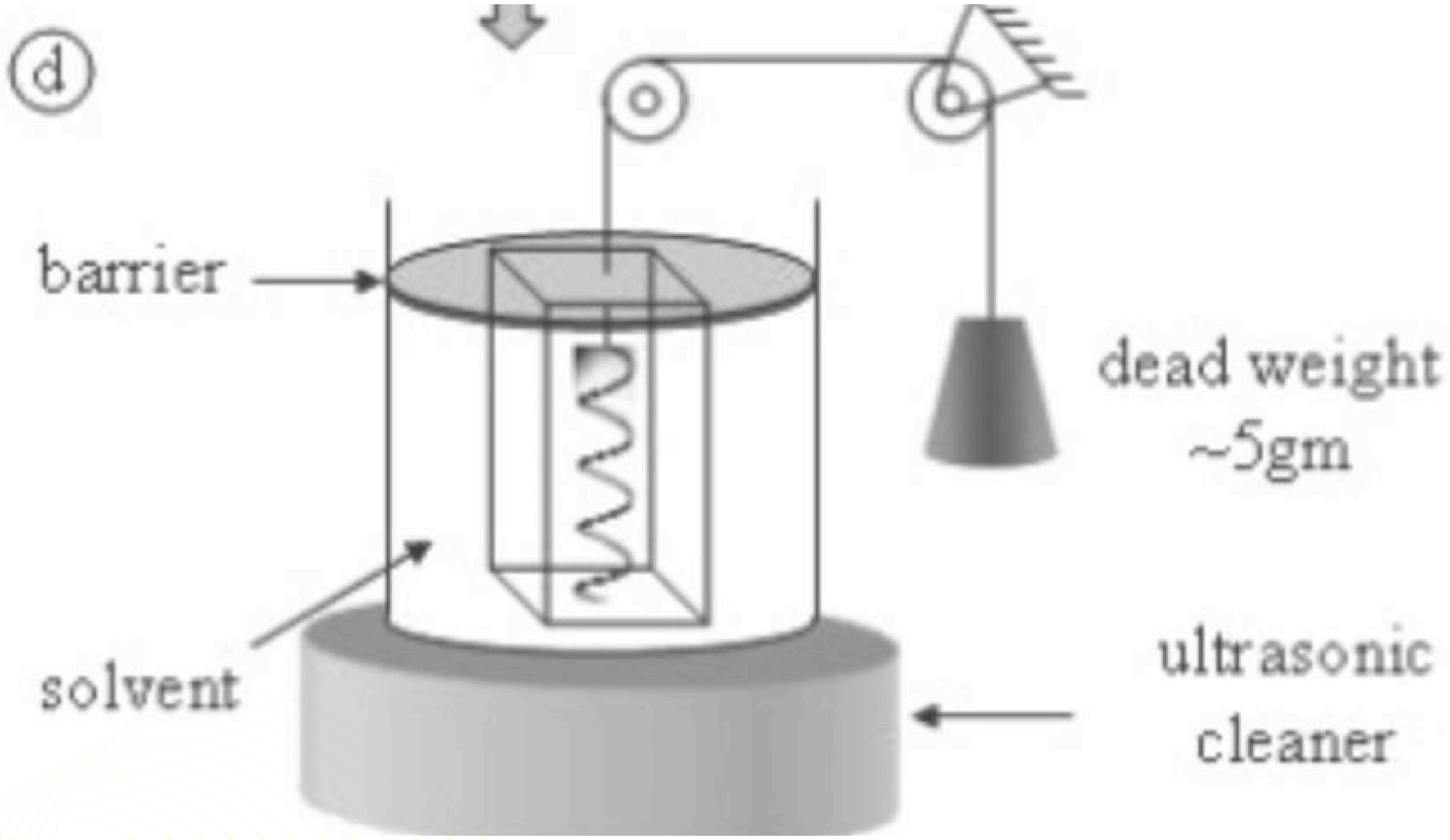


C)Swollen PDMS .



## REMOVE NYLONE THREAD

D). We fastened also a small weight (  5 g) to the thread that went over a pulley. The whole arrangement was then placed inside the bath of an ultrasonic cleaner. Under the action of the small tensile load along with the vibration caused by sonication, the thread came out of the network within 10-15 min



## APPLICATIONS OF HELICAL CHANNEL PDMS

- **1. Biomedical Devices:**
- Lab-on-a-Chip: Enables complex analyses like blood tests and DNA sequencing.
- Cell Sorting: Efficiently separates cells for research and diagnostics.
- **2. Chemical Synthesis:**
- Continuous Flow Reactors: Facilitates controlled chemical reactions with high yield.
- Nanoparticle Synthesis: Produces uniform nanoparticles for various applications.
- **3. Environmental Monitoring:**
- Water Testing: Rapidly detects pollutants in water samples.
- **4. Drug Delivery:**
- Targeted Release: Controls the release rate of drugs for precise treatment.
- **5. Food and Beverage Industry:**
- Quality Control: Ensures product consistency and safety.

## CASE STUDY: LAB-ON-A-CHIP WITH HELICAL CHANNELS

- **Objective**: Improve fluid mixing and reaction efficiency.
- **Results:**
  - **Enhanced Sensitivity:** Detects lower concentrations of analytes.
  - **Faster Processing**: Reduces time required for assays.
- **Conclusion**: Helical channels significantly improve the performance of lab-on-a-chip devices.

## FUTURE DIRECTIONS

- **Material Innovation:** Explore alternative materials for more robust and chemically resistant channels.
- **Integration with Other Technologies:** Combine with sensors and actuators for more advanced systems.
- **Industrial Applications:** Develop large-scale microfluidic systems for chemical manufacturing.

# CONCLUSION

- **Summary:** Helical channels in PDMS offer significant advantages in microfluidic systems, enhancing efficiency in various applications.
- **Impact:** Potential to revolutionize fields like diagnostics, chemical synthesis, and environmental monitoring.
- **Closing Remarks:** Continued research and innovation will expand the possibilities of helical channel microfluidics.


THANK YOU!