Nanofluidic transport and formation of nano-emulsions

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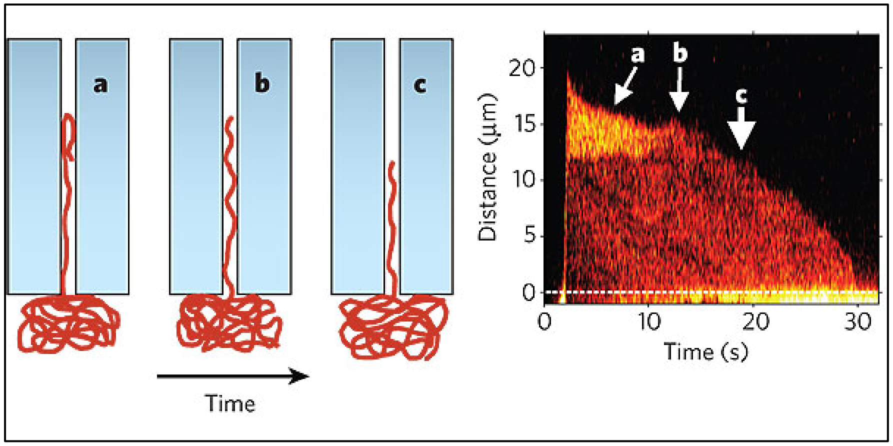
Overview

- Motivation
- Goals
- Experimental Procedure
- Results and Discussion
- Conclusion
- Acknowledgements

Motivation

- **Industry**
  - DNA and protein analysis
  - Cell biology and manipulation



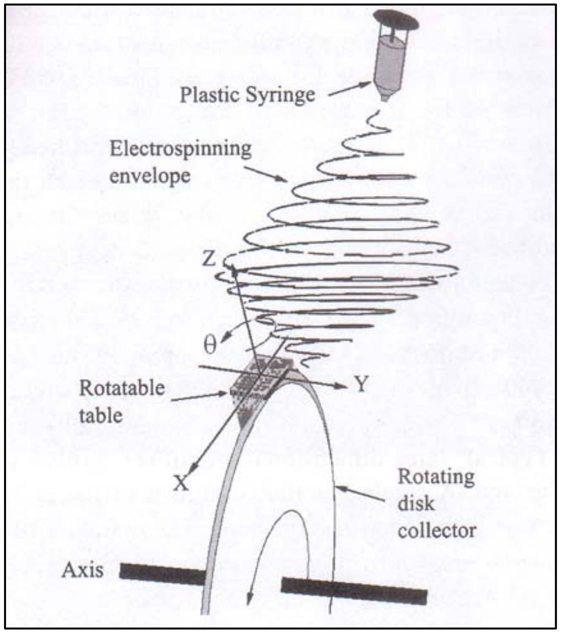
Craighead, Nature, Vol. 442, 2006

Goals

- Record development of emulsions
- Derive volumetric flow
- Find nanochannel diameter

- Make two-phase model
- Study distribution of decane

Experimental Procedure - 1



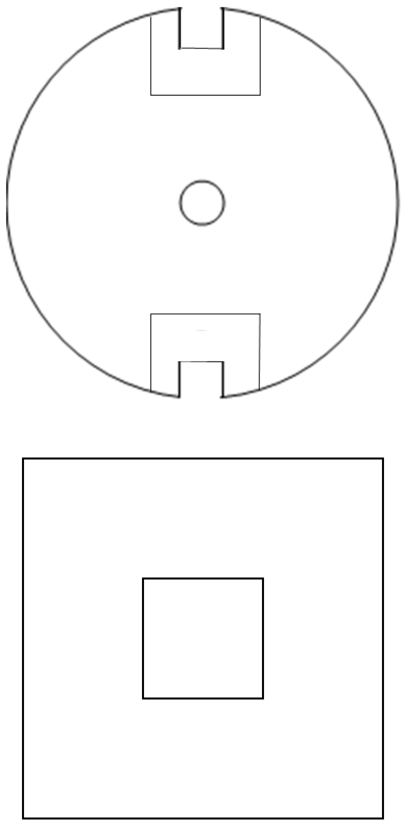
- **Electrospinning**
  - PCL
  - Syringe pump
  - DC generator
  - Rotating disk collector

A.L. Yarin et al., *Advances in Applied Mechanics*, Vol.41,2007

Experimental Procedure - 2

◆ Electrospinning Cont’d.

- Aluminum strips
- Rectangular slots



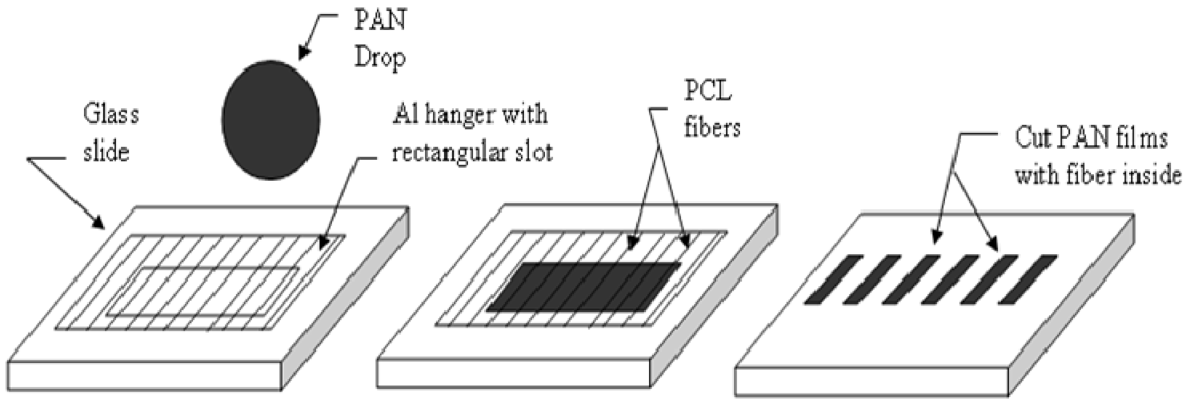
Experimental Procedure - 3

Addition of PAN

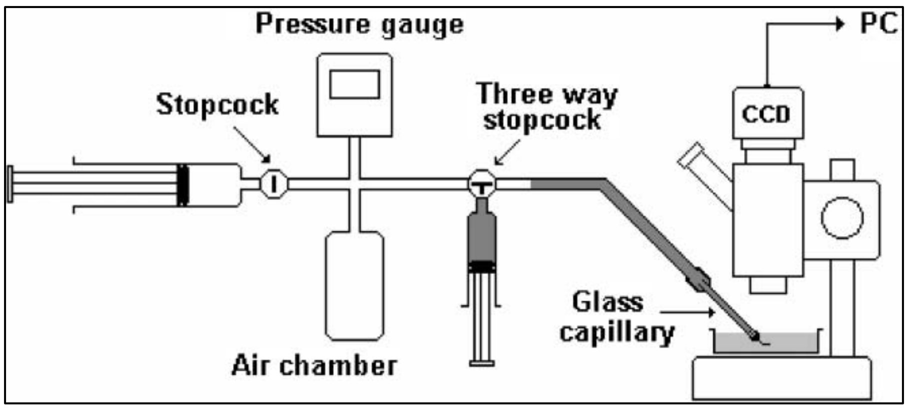
- Addition of PAN to rectangular slot

Heat Treatment

- 350°C for 3 hours, 750°C for 1 hour



Experimental Procedure - 4



A.L.Yarin et al., **Lab on a Chip**, Vol.8, 2008,

◆ Fluid Flow System

- Add decane at three-way stopcock
- Pressurize system at one-way stopcock
- Record emulsions with CCD camera

Results and Discussion - 1

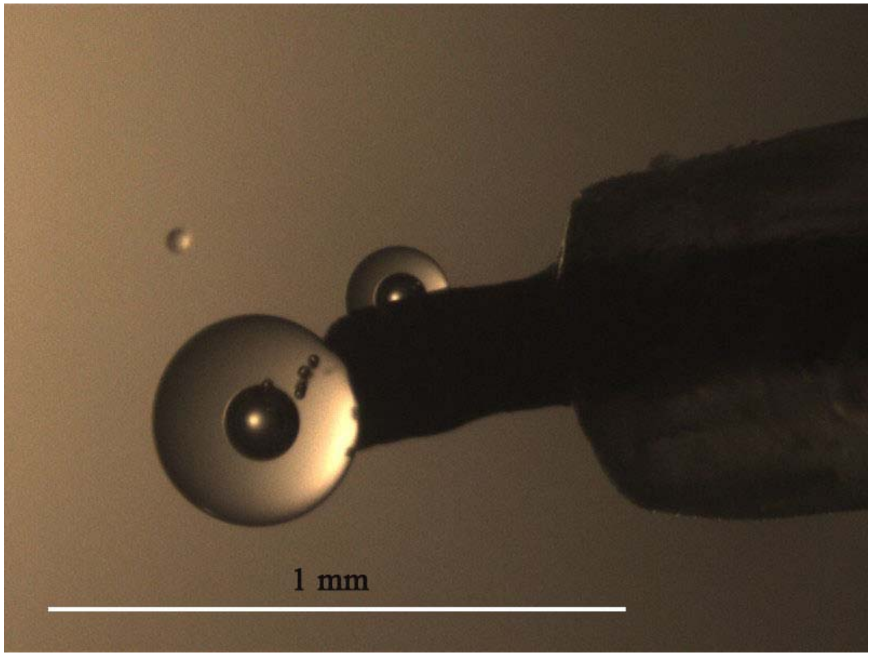
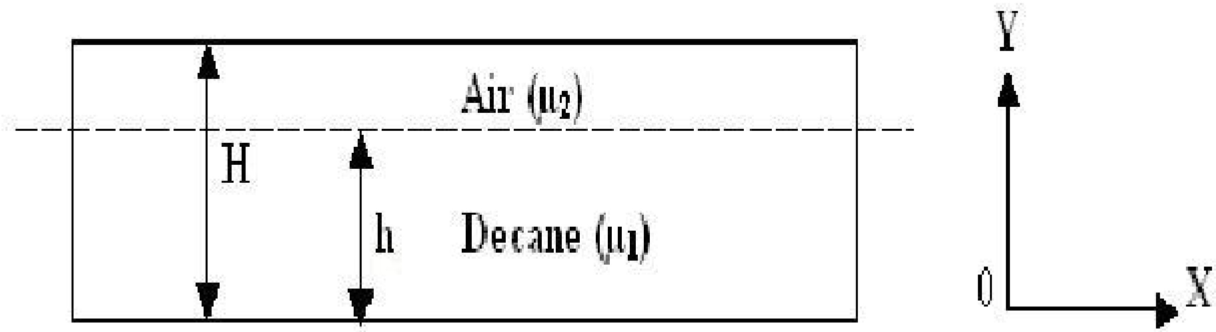


Image of decane and air through nanochannel, taken by Suman Sinha Ray 2008

- **Nanochannel Experiments**
  - Recorded development of emulsions
  - Derived volumetric flows
  - Could not find nanochannel diameters (Poiseuille law)

Results and Discussion - 2



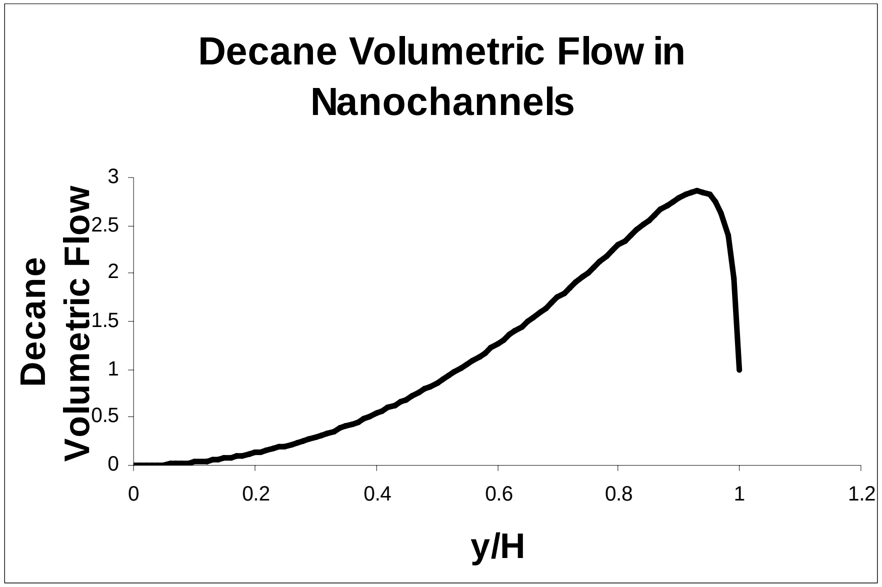
◆ Two-Phase Model

- Assume slit with two layers
- Analyze decane and air in flow
- Derive volumetric flow rates and velocity profiles

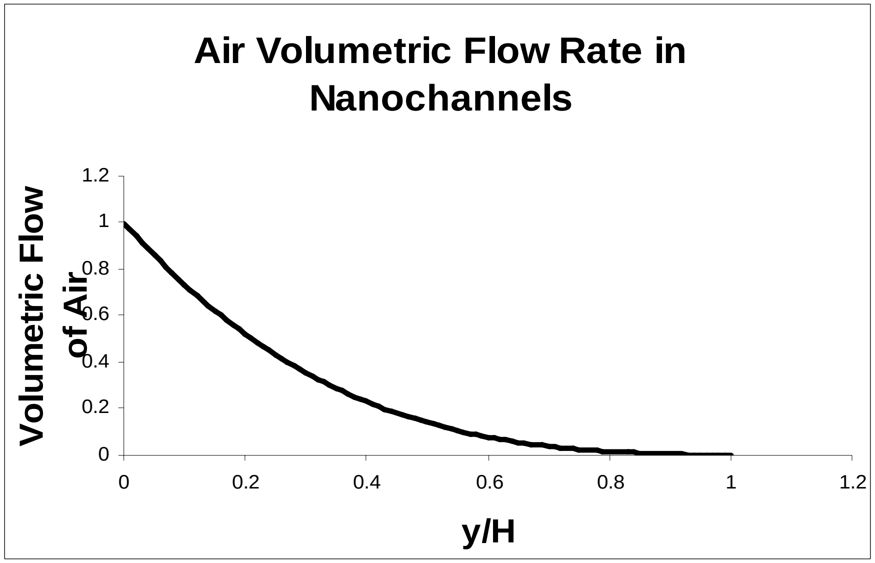
Results and Discussion - 3

◆ Volumetric Flow Rates

- Decane overshoot to ~3
- Decane interactions with air
- Decane reaches purity and acts normally

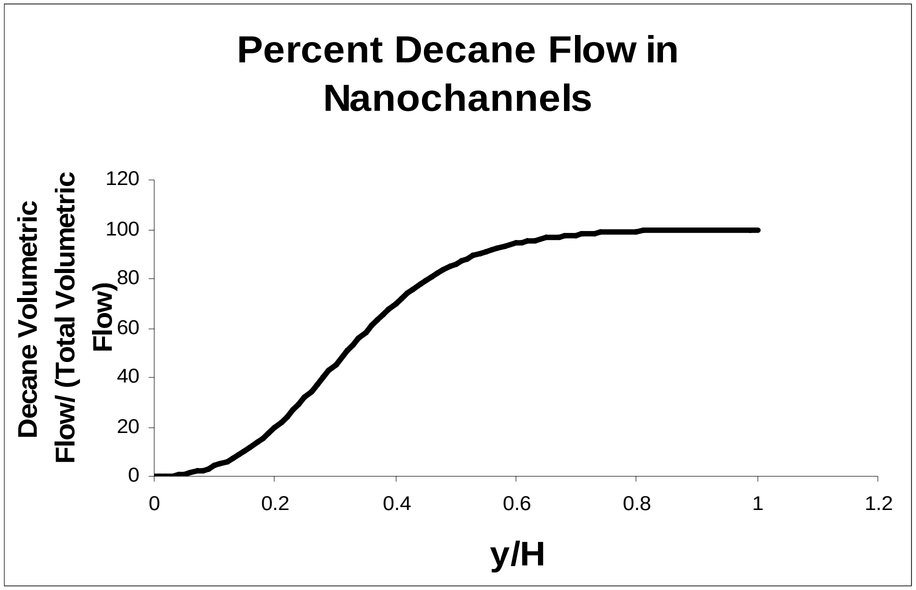


Results and Discussions - 4



- **Volumetric Flow Rates Cont'd**
  - Air has parabolic behavior
  - Decane much more viscous than air

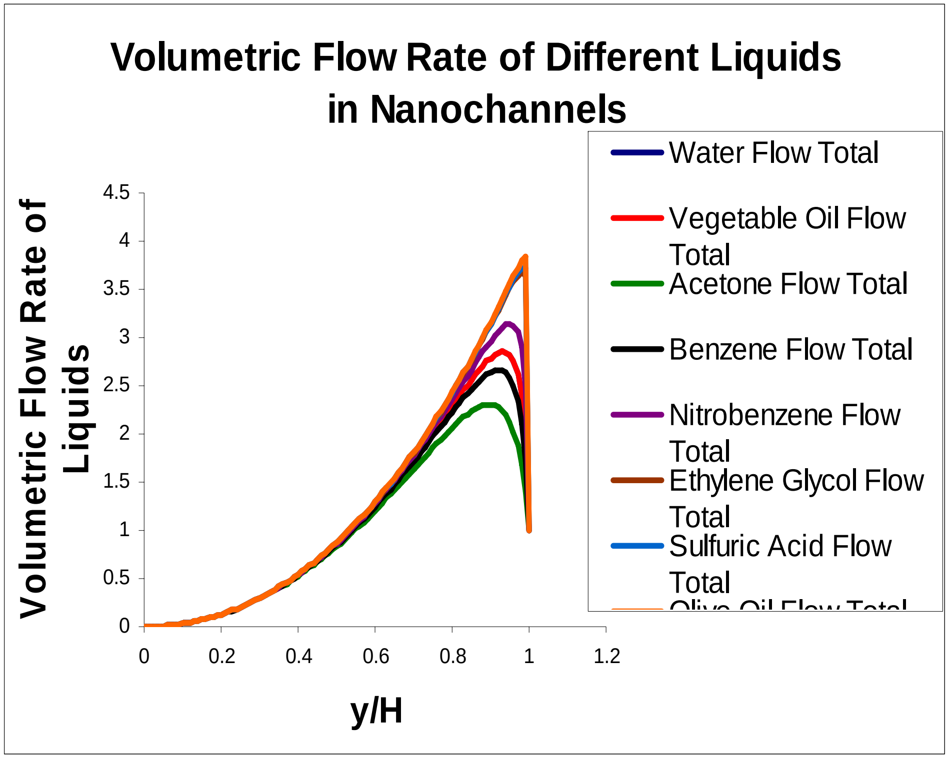
Results and Discussions - 5



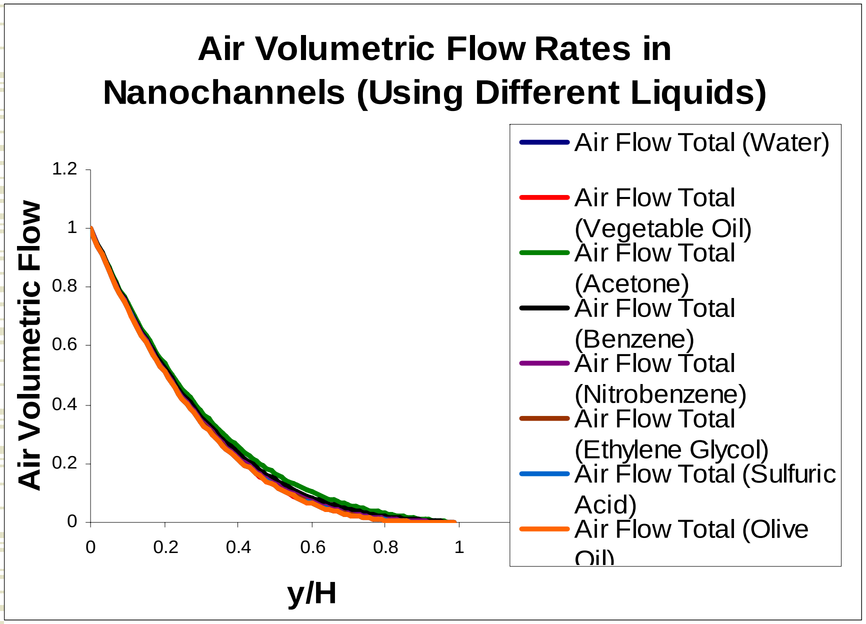
- Volumetric Flow Rates Cont’d
- Percent decane flow in nanochannels
- Used for later analysis

Results and Discussion - 6

- **Different Liquid Simulations**
  - Different liquids followed same behavior
  - Viscous fluids shifted to right and increased



Results and Discussion - 7

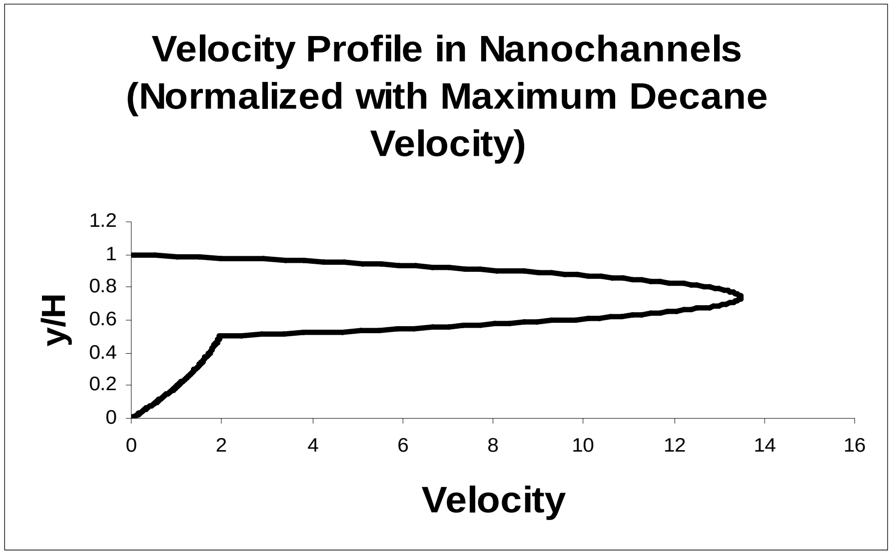


- **Different Liquid Simulations Cont'd**
  - Air flows followed same behavior
  - Deviations were minimal

Results and Discussion - 8

◆ Velocity Profiles

- Used to confirm volumetric flows
- Air moves much faster than decane
- Conclusions supported by profiles



Results and Discussion - 9

◆ Final Analysis

- Assume H = 1μm
- Assume L = 1cm
- Found distribution of decane in nanochannels (h)

Pressure (Pa)	Length (cm)	Air Vol. Flow ($nLsec^{-1}$)	Decane Vol. Flow ($nLsec^{-1}$)	Total Flow ($nLsec^{-1}$)	Decane Flow (%)	y/H	H (μm)	h (nm)
49200	1	0.1324	1.584	1.716	92.290	0.57	1	569
48400	1	0.1075	2.342	2.450	95.612	0.63	1	630
121000	1	1.3531	7.886	9.239	85.354	0.49	1	494
54400	1	0.3	2.969	3.269	90.801	0.55	1	549

Conclusion

- Unable to find the nanochannel diameter based on experimental flows
- Created a two-phase model
- Found the distribution of decane in the nanochannels
- Discovered that the presence of air in nanochannels does influence the decane flow

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References

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- A.V. Bazilevsky, A.L. Yarin and C. Megaridis: Lab. Chip, 2008, 8, 152-160
- SEM Images of Nanochannels. Photos taken by Suman Sinha Ray. (2008) Ongoing Research.
- Rotating Disk Image and Aluminum Sheet Image Courtesy Suman Sinha Ray
- PAN Diagram photo courtesy Suman Sinha Ray