PDMS and PNIPA Processing
Polymer: Poly (N-Isopropoylacrylamide)
  - Useful in area of drug delivery
  - Sharp phase transition
  - Small temperature shift causes significant gel characterization change
  - Addition of hydrophilic or hydrophobic material increases or reduces the transition temperature
  - Hydrophilic: E.g. Acrylamide or Acrylic acid
  - Hydrophobic: E.g. Butylmethacrylate
Gel Processing

1. Initiation
2. Propagation
3. Polymerization
4. Crosslinking with MBA
Materials and Composition

- N,N,N’,N’-tetramethyl-ethylene-diamine (TEMED)
- Ammonium persulfate (APS)
- N,N’-methylene-bis-acrylamide (MBA)
- Acrylamide (AAm)
- Butyl Methacrylate (BMA)
- Water
- Ice

<table>
<thead>
<tr>
<th>Compound</th>
<th>PNIPA</th>
<th>AAm¹</th>
<th>BMA²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gel Code</td>
<td>Mass (g)</td>
<td>Mol %</td>
<td>Mass (g)</td>
</tr>
<tr>
<td>A1</td>
<td>0.7776</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>B1</td>
<td>0.7387</td>
<td>95</td>
<td>0.0244</td>
</tr>
<tr>
<td>B2</td>
<td>0.6998</td>
<td>90</td>
<td>0.0488</td>
</tr>
<tr>
<td>B3</td>
<td>0.6610</td>
<td>85</td>
<td>0.0733</td>
</tr>
<tr>
<td>C1</td>
<td>0.7387</td>
<td>95</td>
<td>-</td>
</tr>
<tr>
<td>C2</td>
<td>0.6998</td>
<td>90</td>
<td>-</td>
</tr>
</tbody>
</table>

¹AAm is a hydrophilic compound
²BMA is a hydrophobic compound
³The Mol% was based on the amount of NIPA monomer in the pure PNIPA gel
Since the mol % of **APS** is 1.91% based on NIPA monomer, we can calculate the mass as follows knowing that the molecular weight of NIPA and APS are 113g/mol and 228g/mol respectively.

\[
\frac{x \cdot 228}{0.7776} \cdot \frac{100\%}{113} = 1.91\%
\]

\[
x = 0.02997g = 29.97mg
\]

We can calculate the weight for MBA and TEMED in a similar fashion.

**MBA:**

\[
\frac{x \cdot 154}{0.7776} \cdot \frac{100\%}{113} = 1.15\%
\]

\[
x = 0.012186g = 12.19mg
\]

**TEMED:**

\[
\frac{x \cdot 116}{0.7776} \cdot \frac{100\%}{113} = 5.82\%
\]

\[
x = 0.04645g = 0.046mL = 46mL
\]

Since the TEMED is a liquid, we have assumed a density of 1g/mL to convert mass to volume.
Add the polymer to the curing agent in a 10:1 ratio

Allow to cure

- Room Temp (48 hours)
- 80°C (2.5 hours)
- 100°C (45 mins)
- 125°C (20 mins)
- 150°C (10 mins)
How can we improve the mechanical properties of hydrogels? What are their drawbacks?

- By increasing the number of crosslinks or by using interpenetrating networks. This tends to reduce the general porosity of the hydrogel and hence the drug loading capability.
In our experiments, we had used resistive heating through the incorporation of wires in the device. How would this heat be implemented in-vivo (in the body)? What other challenges face the clinical application of this device? Any other solutions/suggestions?

- Alternating magnetic fields, radio frequency waves or use of rechargeable batteries.
Questions

- What happens to the average polymer chain length with increased APS and TEMED (initiators) concentration?
  - It increased because the reaction can proceed for a longer period and hence generate more polymers and polymer chains.
Suggestions For Future work

- Improving the mechanical properties of the gels
  - Largely limits their applications in drug delivery
  - IPN can be used but with adequate release characteristics
  - Creep and Visco-elastic properties should also be studied

- *In-vitro* and *In-vivo* studies using the device
  - Work done was to show proof of concept
  - Needed to confirm mechanism in a way that allows programming
  - Miniaturization of the device needed for *in-vivo* studies

- Understanding the underlying mechanisms of synergy
  - Provided synergy in terms of structural changes
  - What is the effect of treatment schedule? Heat before drug or vice-versa. What is the effects of simultaneous application of heat and drug?