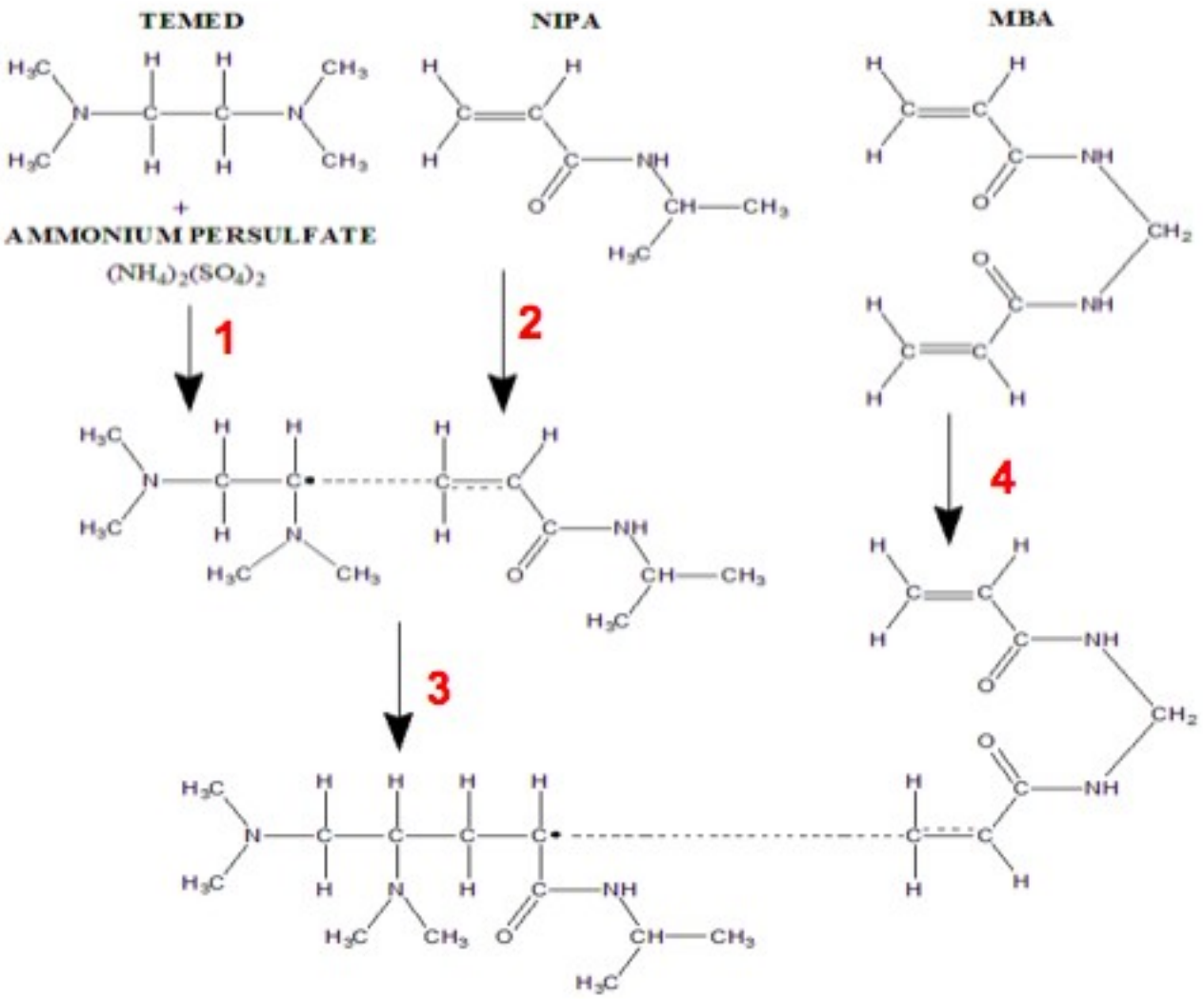
Tuesday, September 13, 2011

PDMS and PNIPA Processing

PNIPA

- 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 acidHydrophobic: E.g. Butylmethacrylate

Gel Processing



1. Initiation
2. Propagation
3. Polymerization
4. Crosslinking with MBA

Materials and Composition

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

Compound	PNIPA		AAm[1]		BMA[2]	
Gel Code	Mass (g)	Mol %[3]	Mass (g)	Mol %[3]	Volume (mL)	Mol %[3]
A1	0.7776	100	-	-	-	-
B1	0.7387	95	0.0244	5	-	-
B2	0.6998	90	0.0488	10	-	-
B3	0.6610	85	0.0733	15	-	-
C1	0.7387	95	-	-	0.055	5
C2	0.6998	90	-	-	0.109	10

[1]AAm is a hydrophilic compound
[2]BMA is a hydrophobic compound
[3]The Mol% was based on the amount of NIPA monomer in the pure PNIPA gel

Calculations

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.

$$\frac{x/228}{0.7776/113} \times 100\% = 1.91\%$$

$$x = 0.02997g = 29.97mg$$

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

MBA:

$$\frac{x/154}{0.7776/113} \cdot 100\% = 1.15\%$$

$$x = 0.012186g = 12.19mg$$

TEMED:

$$\frac{x/116}{0.7776/113} \cdot 100\% = 5.82\%$$

$$x = 0.04645g = 0.046mL = 46mL$$

Since the TEMED is a liquid, we have assumed a density of 1g/mL to convert mass to volume

PDMS

- Add the polymer to the curing agent in a 10:1 ratio
- Allow to cure
  - Room Temp (48 hours)
  - 80C (2.5 hours)
  - 100C (45 mins)
  - 125C (20 mins)
  - 150C (10 mins)

Questions

- 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.

Questions

- 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?