Appendix A

The Product Design Specification of the Mechanical Testing System Coupled with an Environmental Chamber for Hydrogels: Procedure for Making Polydimethyl Siloxane (PDMS) Stencils

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9/27/02

Function: To establish a procedure to make tension stencils, which follow the American Society for Testing Materials (ASTM) standards.

Client Requirements:

- Fast, exact procedure to make ASTM approved PDMS stencils
- Method to ensure uniform thickness and area of stencils, reducing anisotropy in hydrogel samples

Design Requirements:

1. **Physical and Operational Characteristics**

    a. *Performance Requirements:* The stencil made should be disposable. The procedure should allow multiple stencils to be made at one time.

    b. *Safety:* Be careful when using the hot plate because it is very hot. Although, the materials used are nontoxic, gloves should be worn. Hexanes are used to clean any residues of PDMS and it is very toxic volatile. All cleaning shall be performed under a chemical hood.

    c. *Accuracy and Reliability:* The mixture of silicone elastomer and curing agent must be homogenous and properly degassed.

    d. *Life in Service:* Ideally, the stencil shall be used only once. However, if the stencil is to be used more than once, the researcher must use their best judgment in assessing the integrity of the stencil following each usage.

    e. *Shelf Life:* The stencil should be stored in the petri dish in which it is made.

    f. *Operating Environment:* The procedure should be carried out at room temperature and normal humidity.

    g. *Ergonomics:* N/A

h. *Size:* The stencil should be 280 µm thick, have a gauge length of 11 mm, and a neck width of 2 mm.

i. *Weight:* 10 parts by weight of silicone elastomer should be used to 1 part by weight of curing agent. To make one stencil, use 50 g of silicone elastomer and 5 g of curing agent.

j. *Materials:* The following materials should be used: Sylgard ® 184 silicone elastomer, Sylgard ® 184 curing agent, Pyrex ® plates (3 mm thick, 8.5 cm diameter), EPON Master (~280 µm thick, 11 mm gauge length, 2 mm neck width), polystyrene petri dishes (100 mm diameter, 15 mm height), weights – 1 Al plates (3.5 in. diameter, ~102 g) and 3 Al plates (3 in. diameter, ~80 g), tweezers, and transparency sheets.

k. *Aesthetics, Appearance, and Finish:* N/A

2. Production Characteristics

a. *Quantity:* One procedure is needed. Number of stencils required will be determined by individual researchers' needs. Tensile and creep testing for client's current research will require approximately 100 stencils.

b. *Target Product Cost:* NEED TO CHECK ON THIS

3. Miscellaneous

a. *Standards and Specifications:* ASTM guidelines need to be followed.

b. *Customer:* Dr. Weiyuan John Kao, UW-Madison School of Pharmacy & Dept. of Biomedical Engineering

c. *Patient-Related Concerns:* N/A

d. *Competition:* Prof. Beebe and Prof. Crone have similar procedures.

Appendix B

The Product Design Specification of the Mechanical Testing System Coupled with an Environmental Chamber for Hydrogels: Environmental Chamber

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9/27/02

Function: To provide a pH and temperature controlled environment for the tensile testing of hydrogels.

Client Requirements:

- Maintain the pH of a solution determined by experimental design, which will include pH 7.4 and 4.5
- Maintain the temperature of a solution at 37 (± 1) degrees Celsius
- No interference with the dynamic stress-strain relationship, ultimate stress and strain, and yield stress and strain tests
- Compatibility with the Instron 1000 mechanical testing system

Design Requirements:

1. **Physical and Operational Characteristics**

   l. *Performance Requirements:* The environmental chamber should be able to be used as much as necessary (i.e. consecutive tests).

   m. *Safety:* The chamber should be securely sealed to prevent potentially acidic, basic, very hot, and/or very cold solutions from escaping and causing injury to both the user and any surrounding lab equipment. Gloves should be worn when handling the solutions to be used in the chamber. Oven mitts should be worn if the solution to be used is very hot.

   n. *Accuracy and Reliability:* The chamber should not interfere with the mechanical testing of the hydrogels. This is especially important during the preparatory phase of each test, when the researcher is to align the samples between the testing system's grips.

   o. *Life in Service:* The chamber should maintain the temperature and pH of a solution over a time period ranging from 0.5 to 5.0 minutes, the length of each individual mechanical test, which follows ASTM standards.

   p. *Shelf Life:* The chamber should be stored clean and dry in a cool and dry environment.

q. *Operating Environment:* The chamber is to be used at room temperature, atmospheric pressure, and normal humidity. It will also be exposed to solutions with varying temperature and pH, as indicated above.

r. *Ergonomics:* The chamber should be easy to transport.

s. *Size:* See the Instron 1000 dimensions (to be attached later). The chamber should be compatible with this machine.

t. *Weight:* The chamber should be light enough to be lifted by one person.

u. *Materials:* The materials of the chamber should be durable, transparent, easy to manufacture, affordable, insulating, and able to withstand changes in temperature from 20 - 40 degrees Celsius and changes in pH from 4-8.

v. *Aesthetics, Appearance, and Finish:* The chamber should have a transparent shell so that the user can see the hydrogel sample inside. It should also have no sharp edges or extrusions.

2. Production Characteristics

c. *Quantity:* One environmental chamber is needed.

d. *Target Product Cost:* GET FROM CHRISTY'S NOTEBOOK

3. Miscellaneous

e. *Standards and Specifications:* None.

f. *Customer:* See client requirements.

g. *Patient-Related Concerns:* N/A

h. *Competition:* There exist no environmental chambers designed for use with the Instron 1000.

Appendix C

Procedure for Making Polydimethyl siloxane (PDMS) Stencils of Tension Samples

1. Put on gloves because the elastomer is very sticky.

2. Measure out (by weight) 10 parts of elastomer (large container) to 1 part hardener (small bottle) using separate clean weighing dishes.
    a. To make 1 PDMS Stencil, it is recommended to use 10 grams of elastomer and 1 gram of hardener.
    b. To make 1 PDMS base, in which the stencil will be placed, it's recommended to use 50 grams of elastomer and 5 grams of hardener.

3. Mix the elastomer and the hardener thoroughly with the tines of a plastic fork for approximately 5 minutes.
    a. If it is not mixed well, the PDMS will not cure properly.

4. Pour the mixture into a jar and degas it under vacuum for approximately 1hour.
    a. Make sure all bubbles are gone.
    b. For larger volumes to make more than 1 stencil and 1 base, it may longer than 1 hour.

5. Place EPON Master on top of aluminum disk, which is placed on aluminum foil.

6. Pour just enough degassed mixture over EPON Master to cover about 2/3 of it.
    a. Make sure you pour the mixture slowly starting at the center of the EPON Master; this will prevent forming bubbles.

7. Hold weight and EPON master in hand and gently tip it so that the PDMS mixture moves to cover the entire EPON Master.

8. Place a piece of copy machine transparency over the PDMS.
    a. Make sure transparency has a diameter slightly larger than the EPON master

9. Starting from the center of the master, use a small cylinder (pen or marker) to roll out any bubbles that may have formed under the transparency.
    a. Roll from the center in one direction, and then starting from the center again, roll in the opposite direction.

10. Place pyrex disk on top of transparency. Place aluminum disk on top of the pyrex disk. Place 2 steel weights on top of the aluminum disk to push out any excess PDMS.

a. Hold weights in place as PDMS mixture is pushed out from underneath to prevent the transparency from sliding. Once the setup settles and no longer slides, then may let go.

11. Bake in an oven for 3 hours at 80 ^{o}C.

12. When done baking, let cool to room temperature. Then separate components.
    a. Throw away transparency and aluminum foil.
    b. Clean off any PDMS residues on EPON Master, pyrex disk, and weights with hexanes. This must be performed under a chemical hood.

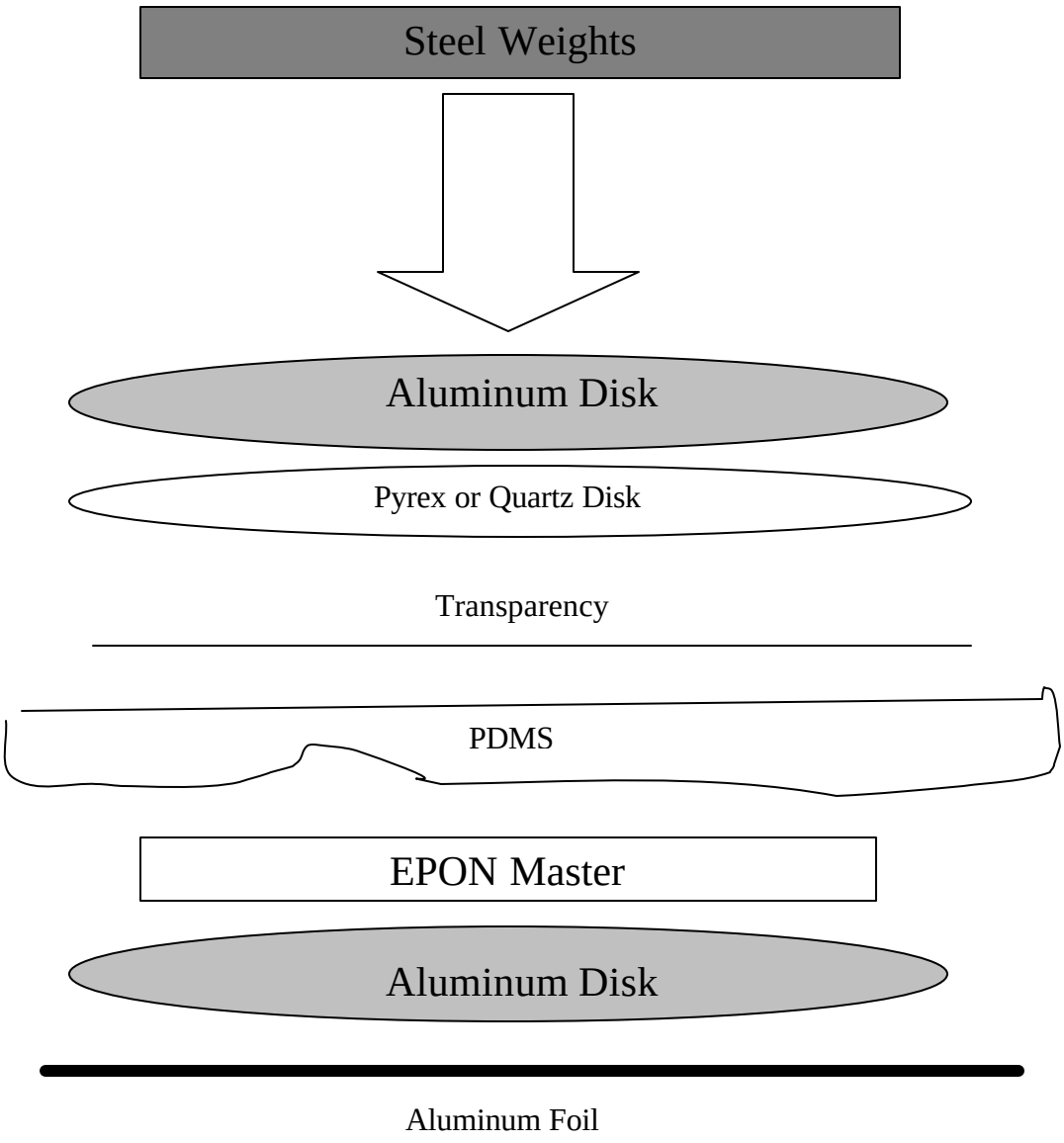

Figure 1. A graphical representation of the PDMS tension stencil procedure assembly.

Appendix D

Base for Tension Samples
And
Cover Slip for Tension Samples

1. Put on gloves because the elastomer is sticky.

2. Measure out (by weight) 10 parts of elastomer (large container) to 1 part hardener (small bottle) using separate clean weighing dishes.
    c. To make 1 PDMS Stencil, it's recommended to use 10 grams of elastomer and 1 gram of hardener.
    d. To make 1 PDMS base, in which the stencil will be placed, it's recommended to use 50 grams of elastomer and 5 grams of hardener.

3. Mix the elastomer and the hardener thoroughly with the tines of a plastic fork for approximately 5 minutes.
    a. If it is not mixed well, the PDMS will not cure properly.

4. Pour the mixture into a jar and degas it under vacuum for approximately 1 hour.
    a. Make sure all bubbles are gone.
    b. For larger volumes to make more than 1 stencil and 1 base, it may longer than 1 hour.

5. Pour degassed mixture into the bottom of the Petri Dish.
    a. Make sure you pour the mixture slowly starting at the center of the Petri Dish; this will prevent forming bubbles.
    b. Fill the Petri Dish up to half of its volume.

6. To make the Cover slip, use the top part of the Petri Dish.
    a. Pour a thin layer of the PDMS solution. It should not reach the border of the Petri Dish. Hold dish in hand and gently tip it so that the layer spreads out towards the edges of the dish.

7. Bake in an oven for 3 hours at 80 ^{o}C.