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Appendixes

Appendix A

Mechanical properties test by Instron universal testing machine

Tensile properties of $BaSO_4$ reinforced PMMA

$BaSO_4$ %	Stress, MPa (at Max. load)	Strain to failure, %	Modulus MPa
0	50.11 (5.17)	5.27 (17.75)	1898 (24.24)
5	49.10 (5.93)	3.47 (22.30)	2984 (31.18)
10	47.86 (5.87)	2.41 (8.70)	3570 (31.18)
20	44.39 (4.62)	2.04 (15.91)	3478 (25.07)
30	40.22 (7.28)	1.92 (22.04)	3882 (17.45)
40	36.46 (8.64)	1.53 (10.10)	4368 (42.00)

- Using MMA is monomer and ASTM D638 mould
- ( ) is coefficient of variation
- Tested with INSTRON 4206-006; EXTENSOMETER 2603-070 TRAVEL 250 mm.

Tensile properties of $BaSO_4$ reinforced PMMA-Co-PEMA

$BaSO_4$ %	Stress, MPa (at Max. load)	Strain to failure, %	Modulus MPa
0	58.61 (8.05)	3.04 (25.74)	2587 (10.32)
5	54.82 (0.90)	2.92 (8.10)	2827 (5.52)
10	49.25 (6.11)	2.29 (25.69)	3394 (18.22)
20	47.46 (2.86)	1.45 (48.77)	4104 (27.04)
30	41.45 (11.19)	1.28 (44.96)	4606 (20.04)
40	36.61 (13.55)	0.90 (67.54)	5438 (17.54)

- Using MMA is monomer and ASTM D638 mould
- ( ) is coefficient of variation
- Tested with INSTRON 4206-006; EXTENSOMETER 2603-070 TRAVEL 250 mm.

Tensile properties of untreated HAP reinforced PMMA-Co-PEMA

HAP %	Stress, MPa (at Max. load)	Strain to failure, %	Modulus MPa
0	58.61 (8.05)	3.04 (25.74)	2587 (10.32)
5	51.09 (8.71)	2.87 (13.57)	2878 (35.98)
10	46.70 (6.25)	2.14 (6.65)	3114 (15.50)
20	42.19 (6.76)	1.94 (43.62)	3386 (19.56)
30	40.01 (1.45)	1.76 (24.94)	3686 (20.13)
40	38.34 (6.42)	1.51 (16.17)	3745 (39.46)

- Using MMA is monomer and ASTM D638 mould
- ( ) is coefficient of variation
- Tested with INSTRON 4206-006; EXTENSOMETER 2603-070
  TRAVEL 250 mm.

Tensile properties of PMMA-Co-PEMA bone cement reinforced with HAP having 3.72 weight percent silane content

HAP %	Stress, MPa (at Max. load)	Strain to failure, %	Modulus MPa
0	58.61 (8.05)	3.04 (25.74)	2587 (10.32)
5	55.29 (4.90)	2.56 (9.89)	3346 (4.93)
10	47.09 (2.78)	1.98 (10.14)	3888 (19.06)
20	44.86 (8.87)	2.00 (6.47)	4006 (29.96)
30	43.09 (7.98)	1.87 (22.19)	4276 (14.40)
40	35.79 (5.67)	1.15 (27.38)	5283 (18.06)

- Using MMA is monomer and ASTM D638 mould
- ( ) is coefficient of variation
- Tested with INSTRON 4206-006; EXTENSOMETER 2603-070
  TRAVEL 250 mm.

Tensile properties of PMMA-Co-PEMA bone cement reinforced with HAP having 5.21 weight percent silane content

HAP %	Stress, MPa (at Max. load)	Strain to failure, %	Modulus MPa
0	58.61 (8.05)	3.04 (25.74)	2587 (10.32)
5	47.12 (16.32)	1.83 (10.72)	3829 (7.49)
10	44.10 (14.20)	1.61 (22.21)	4182 (19.56)
20	42.94 (6.92)	1.54 (22.29)	4527 (36.60)
30	36.41 (9.45)	1.26 (11.16)	5881 (21.04)
40	35.51 (6.90)	1.03 (29.93)	4863 (20.44)

- Using MMA is monomer and ASTM D638 mould
- ( ) is coefficient of variation
- Tested with INSTRON 4206-006; EXTENSOMETER 2603-070 TRAVEL 250 mm.

Tensile properties of PMMA-Co-PEMA bone cement reinforced with HAP having 7.83 weight percent silane content

HAP %	Stress, MPa (at Max. load)	Strain to failure, %	Modulus MPa
0	58.61 (8.05)	3.04 (25.74)	2587 (10.32)
5	52.14 (11.81)	2.66 (15.93)	3277 (12.11)
10	50.53 (5.56)	2.22 (13.27)	3505 (18.74)
20	45.59 (9.15)	2.06 (18.32)	3844 (7.73)
30	40.96 (3.88)	1.49 (16.92)	4134 (12.84)
40	35.93 (7.96)	1.33 (21.58)	4767 (2.00)

- Using MMA is monomer and ASTM D638 mould
- ( ) is coefficient of variation
- Tested with INSTRON 4206-006; EXTENSOMETER 2603-070 TRAVEL 250 mm.

Appendix B
Calculation works

- Calculation of silane content

Hydroxyapatite (HAP) is treated at 0.5 5 of solvent by silane coupling agent (3-trimethoxylsilylpropylmethacrylate). HAP is weighted 50 g, adds with silane agent 2.5 ml and solvent 500 ml (acetone 70 : water 30). After, HAP treated with silane is weighted approximately 1.0 g (W_{hs}). Then, bring it to add in crucible which knows weight (W_c), burns in oven at 550 °C until polymer part in silane agent decomposes. The later, crucible is weighted again (W_{hc}). Moleculare weight is MW.

% Silane treated on HAP = [Weight of silane / Weight of HAP treated with silane] x 100

Weight of silane = Mole of polymer part x Molecular weight of silane agent

Mole of polymer part = Loss weight of HAP / Molecular of weight of polymer part

= Loss weight of HAP / (MW. of polymer part - MW. of silica)

= (W_{hs} + W_c - W_{hc}) / (248.35-28.08)

= (W_{hs} + W_c - W_{hc}) / 220.27

So, % silane treated on HAP $= [(W_{hs} + W_c - W_{hc}) \times$

$$248.35 \, / \, 220.27 \, W_{hs} \,] \times 100$$

- Calculation of void content

Bring the sample to weight in air (W_{sa}) and water (W_{sw}). Crucible is weighted in air (W_c) and then added by sample. Bring both crucible and sample are burnt until resin decomposes which it had residual only reinforcement. After bring reinforcement and crucible weight in air together (W_1).

% Void $=$ (Volume of void x 100) / volume of sample

Volume of void $=$ Volume of sample - [Volume of resin + Volume of reinforcement]

Volume of sample $=$ Weight of sample / Density of sample

$= W_{sa}$ / Density of sample

$= (W_{sa}$ / density of water $) \times (W_{sa} - W_{sw})/W_{sa}$

$= W_{sa} - W_{sw}$

Volume of resin $=$ Weight of resin / Density of resin

$= (W_{sa} + W_c - W_1)$ / Density of resin

Volume of reinforcement $=$ Weight of reinforcement / Density of reinforcement

$= (W_1 - W_c)$ / Density of reinforcement

Appendix C

Basic of instruments

- Universal testing machine

The mechanical properties are often the most important properties because virtually all use conditions and the majority of end-use applications involve some degree of mechanical loading. The material selection for a variety of application is often based on mechanical properties, such as tensile strength, modulus, elongation, and impact strength. Since the published values of the mechanical properties of polymers are generated from tests conducted in a laboratory under standard test condition, the danger of selection and specifying a material from these values is obvious. Stress-strain measurements are generally made instrument by stretching the specimen at a uniform rate and simultaneously measuring the force on the specimen. The test is continued until the specimen breaks. The change in length is determined from measurements of seperation of the jaw or clamps holding the specimen. Although, this is the simplest way of determining the elongation, it can lead to serious errors because there is always some slippage in the specimen grips which this leads to an apparent elongation greater than the true elongation and the restrictions of specimen during near the clamps the test specimen is forced to retain its original width and thickness, so the whole specimen can not stretch uniformly. The best way of measuring the elongation is to use a seperate device attached to the specimen inside the clamps. In many instruments the seperation of the specimen grip is indirectly

measured by synchornizing the time scale of a recorder with elongation in the specimen, this is possible when the rate of seperation of the specimen clamps is constant. The total load on the specimen is measured by strain gauges (extensometer) or by differential transformers.

The basic understanding of stress-strain behavior of plastic materials is almost important to design engineers. The stress-strain diagram shown in Figure A is typical of tension for a constant rate of loading. The initial portion of the stress-strain curve between points A and C is linear and it follow Hooke's law which the actual curve deviates from the straight line is called the proportionally limit, it means that only up to this point is stress proportional to strain. The behavior of plastic material below the proportional limit is elastic in nature. The deformations up to point B in this Figure have been associated with the bending and stretching of the interatomic bonds between atoms of plastic molecules. For values of generally mechanical properties can be detected by these parameters. (a) Stress is a force applied to produce deformation in a unit area of a test specimen, which is a ratio of applied load to the original cross-sectional area. (b) Strain is a ratio of the elongation to the gauge length of the test specimen (Δ l/l). It is expressed as a dimensionless ratio or as percent of strain in (Δ l/l) x 100. (c) Modulus of elasticity is a ratio of stress to corresponding strain below the proportional limit of a material. It is expressed in F/A or slope of graph. This is also known as Young's modulus. A modulus is a measure of material's stiffness.
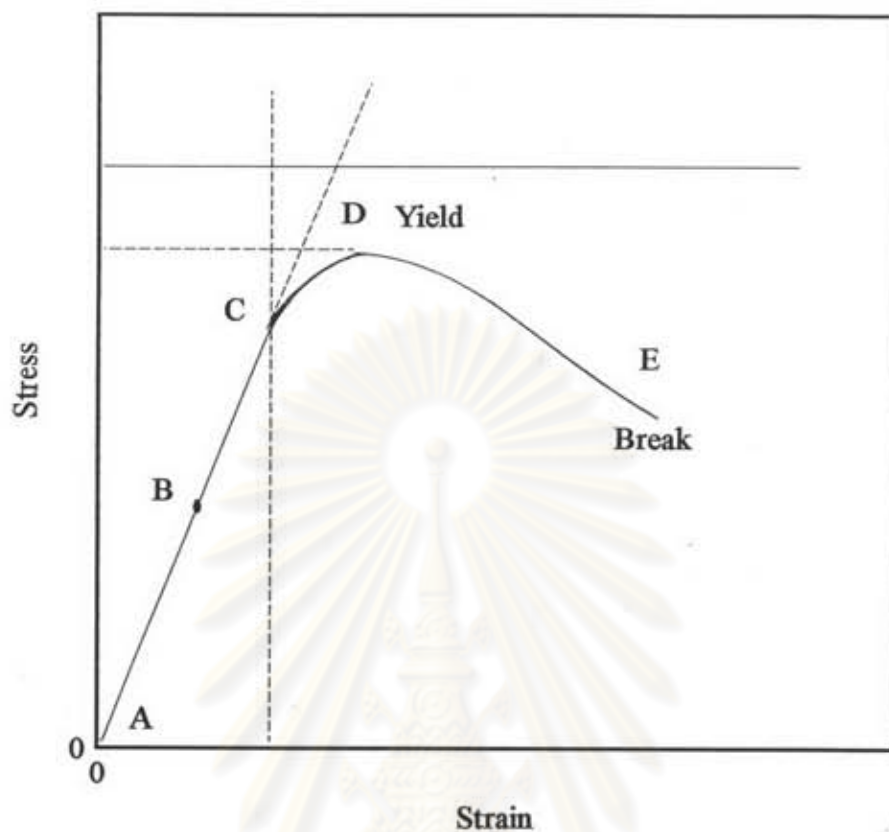
Figure A The stress-strain diagram

- Scanning electron microscope

Scanning electron microscopy instrument using an electron beam as a light source, relate techniques provide a fastinating result which appears to be a true image having depth of focus, high magnification, and superb resolution. It gives an insight into three dimensional details of subject at a submicroscopic level. Its' basic components consist of vacuum system, imaging system, and photographic system. Principle of scanning electron microscopy applies to the electron gun from currency of any desirable KV between 15-20 KV which the primary electrons are emitted. The cloud of emitted primary electrons is condensed to be a

minute beam by the electromagnetic condensing lens and then focused onto the specimen surface. At each point where the primary electrons interact on surface of the specimen, the secondary electrons are generated, detected, and collected in the form of signals by the scintillator unit. This signals are conversed into a collective image of the specimen surface by this unit and this image appears on the television screen so that it can be either viewed or photographed at any desirable magnification.

- Particle size analyzer

Sedigraph 5100 is an instrument for analysis particle size distribution of which uses a principle for distribution of powder in a known density and viscosity liquid. The liquid shall be one in which the powder can be completely dispersed, so that the powder separated into unattached particles to give accurate size results. Obviously, the liquid shall be nontoxic, readily available, and one in which the sample is insoluble. In between testing, agitation aids dispersion which perhaps carry out in a high-speed blender, homogeniger, or an ultrasonic device. Then, particle of powder is detected by x-ray beam. Particle is falling due to gravity in a viscous liquid by 3 forces as a gravitational force acting downward, a buoyant force acting upward, and a drag force acting upward, which has come to be identified as the Stokes law. Sedimentation size analysis is based upon the equilibrium velocity of a particle through a viscous medium. Resulting from the action of the gravitational force can be related to the size of the particle by Stokes' law. Data on the sedimentation velocity of suspended particles may be

obtained in 2 ways as by measuring the concentration of particles remaining in suspension as a function of time, or by measuring the quantity of sediment produced as a function of time. The latter approach is less desirable mathematically because of the graphical differentiation requires to reduce the data to a size distribution curve.

VITA

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