

## REFERENCES

- [1] Duchatelard, Ph., Buad, G., Besse, J.P. and Jacquet M. Alumina coatings on PMMA: optimization of adherence. Thin Solid Films (1994): 142-150, 250.
- [2] Lee, C.C., Hsu, J.C. and Jaing, C.C. Optical coatings on polymethyl methacrylate and polycarbonate. Thin Solid Films (1997): 122-124, 295.
- [3] Urreaga, J.M., Matias, M.C., Lorenzo, V. and Orden, M.U. Abrasion resistance in the tumble test of sol-gel hybrid coatings for ophthalmic plastic lenses. Materials Letters (2000): 293-297, 45.
- [4] Innocenzi, P., Brusatin, G., Guglielmi, M. and Bertani, R. New synthetic route to (3-Glycidoxypropyl)trimethoxysilane-Based hybrid organic-inorganic materials. Chem. Mater. (1999): 1672-1679, 11.
- [5] Chen, J.I., Chareonsak, R., Puengpipat, V. and Marturunkakul S. Organic/inorganic composite materials for coating applications. Journal of Applied Polymer Science (1999): 1341-1346, 6.
- [6] Lee, M.S. and Jo, N.J. Coating of methyltriethoxysilane-modified colloidal silica on polymer substrates for abrasion resistance. Journal of Sol-Gel Science and Technology (2002): 175-180, 24.
- [7] Brinker, C.J. and Scherer, G.W. The Physics and Chemistry of Sol-Gel Processing. Sol-Gel Science (Academic Press, Inc.: New York, 1990).
- [8] Wen, J. and Wilkes G.L. Organic/inorganic hybrid network materials by the sol-gel approach. Chem. Mater. (1996): 1667-1681, 8.
- [9] Prassas, M. and Hench, L.L. Ultrastructure Processing of Ceramics, Glasses, and Composites. (John Wiley & Sons: New York, 1984): 100-125.
- [10] Frank, S. Ophthalmic lens coatings. Surface and Coatings Technology (1996): 79-86, 81.
- [11] Choroenpinijkarn, W., Suwankruhasn, M., Kesapabutr, B., Wongkasemjit, S., Jamieson, A.M. Sol-gel process of silatrane. European Polymer Journal (2001): 1441-1448, 37.

- [12] Li, C., Jordens, K. and Wilkes, G.L. Abrasion-resistant coatings for plastic and soft metallic substrates by sol-gel reactions of a triethoxysilylated diethylenetriamine and tetramethoxysilane. Wear (2000): 152-159, 242.
- [13] Harreld, J.H., Esaki, A. and Stucky, G.D. Low-shrinkage, high-hardness, and transparent hybrid coatings: Poly(methyl methacrylate) cross-linked with silsesquioxane. Chem. Mater. (2003): 3481-3489, 15.
- [14] Li, C. and Wilkes, G.L. The mechanism for 3-aminopropyltriethoxysilane to strengthen interface of polycarbonate substrates with hybrid organic-inorganic sol-gel coatings. Journal of Inorganic and Organometallic Polymer (1998): 33-45, 8(1).
- [15] Wen, J., Vasuddevan, V.J., Wilkes, G.L. Abrasion resistant inorganic / organic coating materials prepared by sol-gel method. Journal of Sol-Gel Science and Technology (1995): 115-126, 5.
- [16] Song, K.C., Park, J.K., Kang, H.K. and Kim, S.H. Synthesis of hydrophilic coating solution for substrate using glycidoxypropyltrimethoxysilane. Journal of Sol-Gel Science and Technology (2003): 53-59, 27.
- [17] Dan, Y., Chen, S.Y. and Lian, T.J. Surface structure and properties of water-based polymer coating materials prepared by the complexation of two polymer lattices with chemically complementary. Journal of Applied Polymer Science (2003): 1748-1754, 90.
- [18] Kim, D.H., Moon, J.H., Lee, D.W. and Shul, Y.G. Investigation of the curing mechanism in the GPTS / APTS binder system. Journal of Sol-Gel Science and Technology (2003): 403-406, 26.
- [19] Steven, R.D., Adrian, R.B. and Alan, A. Formation of silica/epoxy hybrid network polymers. Journal of Non-Crystalline Solids (2003): 197-205, 315.
- [20] Winkler, R.P., Arpac, E., Schirra, H., Sepeur, H., Wegner, I. and Schmidt, H. Aqueous wet coatings for transparent plastic glazing. Thin Solid Films (1999): 209-211.
- [21] Yunfa, C., Lianming, J. and Yusheng, X. Sol-gel processing of organic-inorganic nanocomposite protective coatings. Journal of Sol-Gel Science and Technology (1998): 735-738, 13.

- [22] Daniels, M.W., Francis, L.F. Silane adsorption behavior, microstructure, and properties of glycidoxypropyltrimethoxysilane-modified colloidal silica coatings. Journal of Colloid and Interface Science (1998): 191-200, 204.
- [23] Designation: D 3359-02. Standard test methods for measuring adhesion by tape test. Copyright© ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States, 391-397.
- [24] Colts-Laboratories. (1997). Boiling water adhesion. Colts standard test, L-12-12-01, 1-5.
- [25] Chu, L., Daniels, M.W. and Francis, L.F. Use of (Glycidoxypropyl)-trimethoxysilane as a binder in colloidal silica coatings. Chem. Matter. (1977): 2577-2582, 9.
- [26] Wang, J., Wu, G., Shen, J., Yang, T., Zhang, Q., Zhou, B. and Deng, Z. Scratch-resistant improvement of sol-gel derived nano-porous silica films. Journal of Sol-Gel Science and Technology (2000): 219-224, 18.
- [27] Shoichiro, Y., Keisuke, I. and Kimio, K. Physical properties and structure of organic-inorganic hybrid materials produced by sol-gel process. Materials Science and Engineering (1998): 75-90, 6.
- [28] Yu, Y.Y., Chen, C.Y. and Chen, W.C. Synthesis and characterization of organic-inorganic hybrid thin films from poly(acrylic) and monodispersed colloidal silica. Polymer (2003): 593-601, 44.
- [29] Riegel, B., Blittersdorf, S., Kiefer, W., Hofacker, S., Muller, M. and Schottner, G. Kinetic investigations of hydrolysis and condensation of the glycidoxypropyltrimethoxysilane / aminopropyltriethoxy-silane system by means of FT-Raman spectroscopy. Journal of Noncrystalline Solids (1998): 76-84, 226.

## APPENDICES

### Appendix A The classification of adhesion test

The following method was used to test adhesion on a poly(methyl methacrylate) substrates:

A lattice pattern with either six or eleven cuts in each direction is made in the film to the substrate, pressure-sensitive tape is applied over the lattice and then removed, and adhesion is evaluated by comparison with descriptions and illustrations. Rate the adhesion in accordance with the following scale is illustrated in Table A:

5B The edges of the cuts are completely smooth; none of the squares of the lattice is detached.

4B Small flakes of the coating are detached at intersections; less than 5% of area is affected.

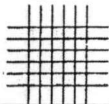
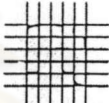
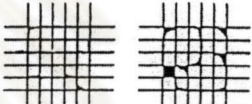

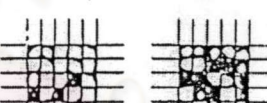
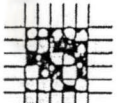
3B Small flakes of the coating are detached along edges and at intersection of cuts. The area affected is 5 to 15% of lattice.

2B The coating has flaked along the edges and on parts of the squares. The area affected is 15 to 35% of the lattice.

1B The coating has flaked along the edges of cuts in large ribbons and whole squares have detached. The area affected is 35 to 65% of the lattice.

0B Flaking and detachment worse than Grade 1.

Table A Classification of adhesion test

Classification of Adhesion Test Results		
Classification	Percent Area Removed	Surface occurrence of crosscut area for six parallel cuts and adhesion range by percent
5B	0% None	
4B	Less than 5%	
3B	5-15%	
2B	15-35%	
1B	35-65%	
0B	Greater than 65%	

ศูนย์วิทยุทันตกรรม  
จุฬาลงกรณ์มหาวิทยาลัย

## Appendix B The standard of steel wool scratch test

The following method was used to test adhesion on a poly(methyl methacrylate) substrates:

This test is performed using #000 or #0000 grade steel wool. The steel wool is rubbed across the substrates surface with a 1.0 kg (2.2 lbs.) force continuously applied for 10 cycles. This rubbing can be done with an oscillating machine such as the Sutherland Abrasion tester or by hand. The surface are graded as a pass if the scratching is less than the following levels in the Table B:

**Table B** The standard of steel wool test

Level of hardness	Number of scratching line
A	0
B	1-3
C	4-20
D	21-40
E	41-100
F	More than 100

Also, the substrates surface shall show no evidence of every fine scratch (fogging) or coating removal.

**CURRENT VITA****MISS. WALAIRAT TANGLUMLERT**

- Date of Birth** : December 31, 1977
- Birth Place** : Chumporn, Thailand
- Martial Status** : Single
- Current Address** : 2130/51 Tumbol Theparak, Amper Muang,  
Samutprakarn, 10270 Thailand
- Education** : 1996-2000 Bachelor Degree of Science in Chemistry, Faculty  
of Science and Technology, Thammasat University, Thailand  
: 2002-2004 Master Degree of Science in Petrochemistry and  
Polymer Science, Faculty of Science, Chulalongkorn  
University, Thailand



ศูนย์วิทยทรัพยากร  
จุฬาลงกรณ์มหาวิทยาลัย