Abstract— Microporous metal-organic polymers have found a wide range of technological applications, such as molecular separation and the prevention of pollution in air, liquid, and water systems, where they can be used as ion exchangers and molecular sieves. These novel zeolite-like materials may be fabricated into nanofibers. Scientist are discovering ways to apply metal-organic nanofibers in nanospace technology. For example, a tiny volume of nanofibers may be used for water and air quality control in space. UH researchers have synthesized the first rational-designed triple-layer two-dimensional coordination polymer. By the use of cobalt atoms as metal centers, the research team has also synthesized a new network metal-organic polymer with a square grid structure. Researchers utilized facilities supported by the National Science Foundation at the Texas Center for Superconductivity on the main campus of the University of Houston.

Investigation of Metal-Organic Polymers & Nanofibers

Jack Y. Lu, Ph.D., Assistant Professor of Chemistry, School of Natural and Applied Science, University of Houston-Clear Lake

SYNTHESISAND FABRICATION OF FUNCTIONAL NANOFIBERS REPresent one of the greatest challenges in materials science and technology. Microporous metal-organic polymers have found a wide range of technological applications, such as molecular separation and the prevention of pollution in air, liquid, and water systems where they can be used as ion exchangers and molecular sieves. These novel zeolite-like materials may be fabricated into nanofibers. Combining the advanced structural features of metal-organic polymers with the fabrication technique, scientists may find the application of metal-organic nanofibers in nanospace technology.

For example, a tiny volume of nanofibers may be used for water and air quality control in space. One of the key factors for the success of the fabrication of metal-organic nanofibers is the synthesis of desirable metal-organic polymers that can be suitable for nanofiber fabrication. UH researchers in the project have produced several novel microporous metal-organic polymers. A few of them have been fabricated into metal-organic fibers.

Experimental Activity

Among the new metal-organic polymers synthesized in UH laboratories, $[Cu_3(N_2C_{12}H_{10})(IN)_6(H_2O)_2]$[1] is the first rationally-designed triple-layer, two-dimensional coordination polymer. (See Structure I.) This unprecedented two-dimensional triple-layer open-framework structure is stack-interlocked into a three-dimensional polymeric coordination network under hydrothermal conditions. The multiple-layer two-dimensional open-framework may have potential applications, such as molecular adsorption and separation. It has attractive features, such as open channels in two-dimensional networks, from both three-dimensional and two-dimensional open-framework structures.

$\{[Cu_2(IN)_3]\cdot I_5^{-.5/6}I_2\cdot H_2O\}_\infty$ (IN: isonicotinato)[2] is an unusual polyiodide inclu-

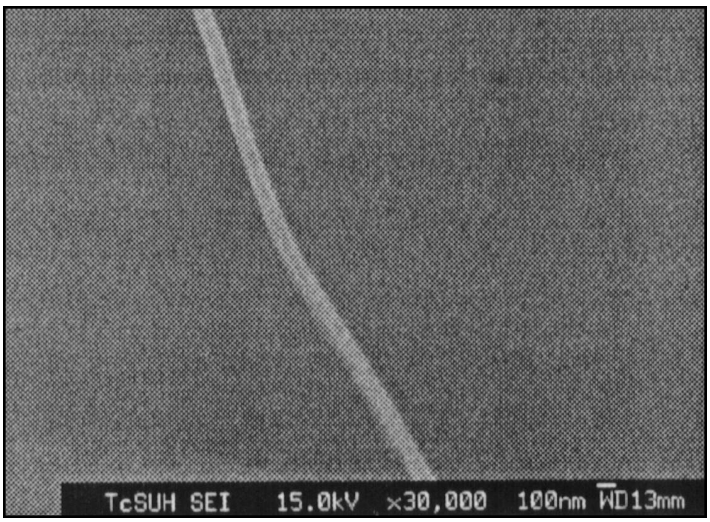


Figure 1. Scanning electron micrograph of the electrospun nanofiber.

sion metal-organic polymer with a novel three-dimensional nano hollow-channel open-framework synthesized by an oxidation reaction route under hydrothermal conditions. The diameter of the channel is about 1.15 nm, slightly smaller than that of carbon nanotubes (~1.4 nm).

The metal-organic polymer, $[Cd(C_{10}H_8N_2)_2](NO_3)_2]$,[3] with square grid structure has been documented to show high shape specificity in molecular adsorption and catalysis. By using cobalt atoms as metal centers with a preference to form octahedral geometry, we have synthesized a new network metal-organic polymer with similar frameworks $(H_2O)_4Co(C_{10}H_8N_2)_3]\cdot 2NO_3\cdot 3.5H_2O$. (See Structure II.) This new metal-organic polymer has been fabricated into metal-organic nanofibers and fibers with rod, flat, hollow, and coil shapes have been observed.[4]

$[(H_2O)_2M(bpy)(bpen)_2]\cdot 1.75(bpen)\cdot 0.25(bpy)\cdot 2NO_3\cdot 4.45H_2O$ (M = *Cd*, *Zn*; bpen = trans-1,2-bis(4-pyridyl)ethylene) has a novel mixed-ligand network structure with large channels filled by solvents and anions. (See structure III.) This material represents the first mixed-ligand and mixed bonding guest-containing acentric framework created by the unbalanced inclusion guest species. This compound is soluble in DMF and several other solvents and can form metal-organic nanofibers. The metal-organic nanofibers generated from this material by the electrospinning technique display diameters from 60 nm to 4 μm[5] (Fig. 1).

$[Cu(NA)_2]$ (NA = nicotinato) is a new three-dimensional neutral open-framework coordination polymer constructed via a square pyramidal binuclear Cu(II) and nicotinato-ligand.[6]

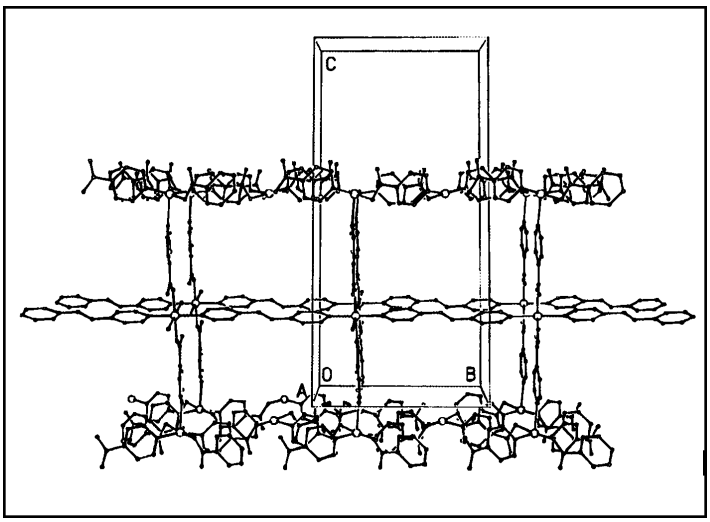
Acknowledgments

Researchers wish to express their appreciation for financial support provided by ISSO. This work made use of MRSEC/TCSUH Shared Experimental Facilities, supported by the National Science Foundation and the Texas Center for Superconductivity at the University of Houston.

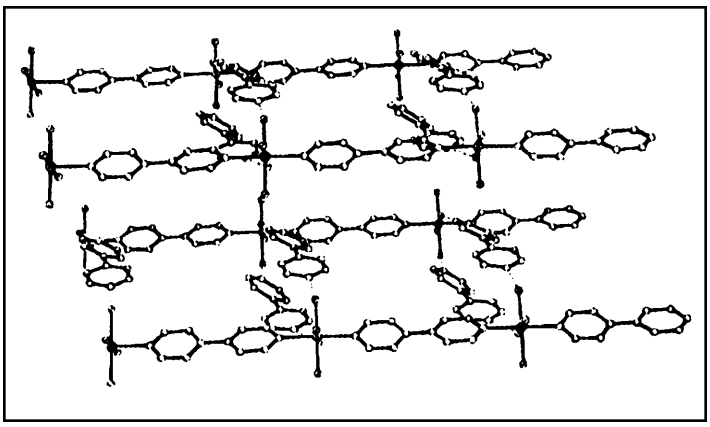
References

[1]J. Y. Lu and A. M. Babb. "The First Triple-Layer 2-D Coordination Polymer: $[Cu_3(bpen)(IN)_6(H_2O)_2]$," *Inorg. Chem.* 40 (2001): 3261-62.

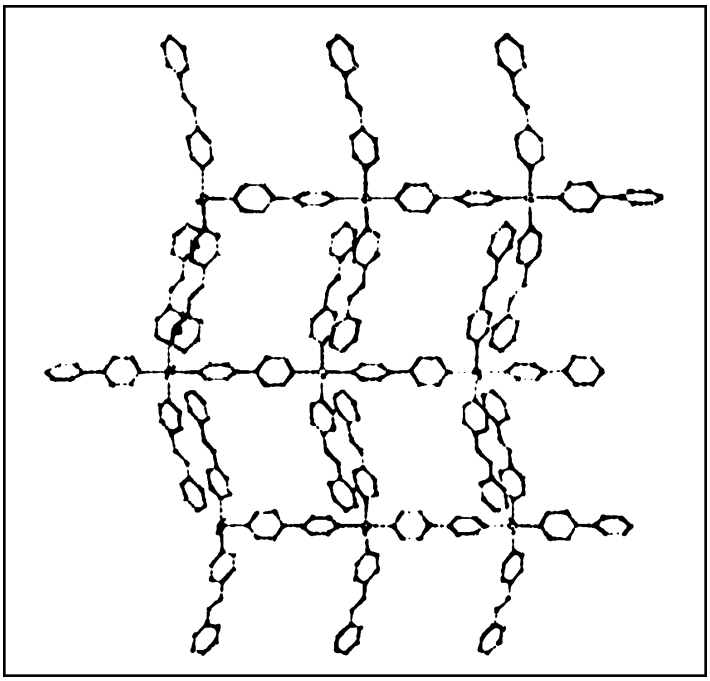
[2]J. Y. Lu and V. Schauss. "A Novel



Structure I. The first rationally-designed triple-layer two-dimensional polymer.



Structure II. A new network metal-organic polymer.



Structure III. A novel mixed-ligand structure with large channels filled by solvents and anions.

Nanostructured Open-Channel Coordination Polymer with an Included Fused Polyiodide Ring," *Eur. J. Inorg. Chem.* (2002). (*In press*.)

[3]M. Fujita, J. W. Kwon, and S. Washizu. "Preparation, Clathration Ability, and Catalysis of a Two-Dimensional Square Network Material Composed of Cadmium (11) and 4,4'-Bipyridine," *J. Am. Chem. Soc*. 116 (1994): 1151-52.

[4]J. Y. Lu, C. Norman, K. A. Abboud, and A. Ison. "Crystal Engineering of an Inclusion Coordination Polymer with Cationic Pocket-Like Structure and its Property to Form Metal-Organic Nanofibers," *Inorg. Chem. Commun*. 4 (2001): 459-61.

[5]J. Y. Lu, K. A. Runnels, and C. Norman. "A New Metal-Organic Polymer with Large Grid Acentric Structure Created by Unbalanced Inclusion Species and Its Electrospun Nanofibers," *Inorg. Chem*. 40 (2001): 4516-17.

[6]J. Y. Lu and A. M. Babb. "A New 3-D Neutral Framework Coordination Polymer Constructed via Square Pyramidal Binuclear Cu(II) and Nicotinato-Ligand," *Inorg. Chem. Commun.* 4 (2001): 716-18.

Publications

Lu, J. Y. and A. M. Babb. "An Unprecedented Interpenetrating Structure with Two Covalent-Bonded Open-Framework of Different Dimensionality," *Chem. Commun*. 9 (2001): 821-22.

Lu, J. Y., K. A. Runnels, and C. Borman. "A New Metal-Organic Polymer with Large Grid Acentric Structure Created by Unbalanced Inclusion Species and Its Electrospun Nanofibers," *Inorg. Chem.* 40 (2001): 4516-17.

Lu, J. Y. and A. M. Babb. "The First Triple-Layer 2-D Coordination Polymer: $[Cu_3(\text{bpen})(\text{IN})_6(H_2O)_2]$," *Inorg. Chem.* 40 (2001): 3261-62.

Lu, J. Y. and K. A. Runnels. "An Unprecedented Mixed-Valent-Copper Metal-Organic Polymer Displaying Graphite-Like Properties," *Inorg. Chem. Commun.* 4 (2001): 678-81

Lu, J. Y. and V. Schauss. "Crystal Engineering of a Three-Dimensional Coordination Polymer Based on Both Covalent and *O-H---O* Hydrogen Bonding Interactions of Bi-Functional Ligand," *Cryst. Eng. Comm*. 3 (2001): 111-13.

Lu, J. Y. and A. M. Babb. "Self-Assembly of Two-Dimensional Coordination Polymers with Rigid and Flexible Building Blocks," *Inorg. Chim. Acta* 318 (2001): 186-90.

Lu, J. Y., C. Norman, K. Abboud, and A. Ison. "Crystal Engineering of an Inclusion Coordination Polymer with Cationic Pocket-Like Structure and Its Property To Form Metal-Organic Nanofibers," *Inorg. Chem. Commun.* 4 (2001): 459-61.

Lu, J. Y. and A. M. Babb. "A New 3-D Neutral Framework Coordination Polymer Constructed via Square Pyramidal Binuclear Cu(II) and Nicotinato-Ligand," *Inorg. Chem. Commun.* 4 (2001): 716-18.

Lu, J. Y., A. L. Reynolds, and K. A. Runnels. "A New Metal-Organic Structure with Alternating One-Dimensional Serpentine Ribbon Chains and Two-Dimensional Layer Networks of Different Topology," *Cryst. Eng. Comm.* 3 (2001): 144-46.

Lu, J. Y., T. J. Schroeder, A. M. Babb, and M. Olmstead. "Two New Coordination Polymers Differentiated by *C-H---O* Hydrogen Bonding." *Polyhedron* 20 (2001): 2445-49.

UHCL ATRIUM—Dr. Jack Lu stands in the central esplanade on the third floor of the Bayou Building of the University of Houston-Clear Lake.