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metal solutions, allowing simultaneous multi-metal analysis. This simplifies sample prep and stabilizes the sample for handling and storage, relative to traditional methods of analysis. Different classes of metals can be similarly preconcentrated by utilizing a different monolayer chemistry in the porous thin film. Thin films of the invention have been successfully deposited on aluminum (Al), steel, glass, and aluminized surfaces. For XRF applications, a preferred film support material can be Al, aluminized glass, or high purity alumina. FNTF films of the invention are physically and hydrothermally stable. The absence of glues or polymer binders limits the introduction of impurities that might complicate the analytical signal, thereby providing a more stable baseline for the analytical procedure. Incorporation of trace amounts of compatible materials within the film may be desirable as a means of creating an internal analytical standard intrinsic to the device.

### CONCLUSIONS

This work has demonstrated that it is easy to produce uniform, crack-free 10-20  $\mu\text{m}$  mesoporous  $\text{SiO}_2$  films using screen printing. For good uniformity in the screen-printing process it is necessary to reduce particle size of the starting silica powder. The particle size of mesoporous  $\text{SiO}_2$  can be reduced to sub-micron sizes using ball milling or attrition milling. By controlling the mill time, it is possible to maintain the ordered pore structure and symmetry of MCM-41. Thickness of the screen-printed film can be controlled by either the screen thickness, or by using multiple printing steps. By judicious choice of calcining (sintering) conditions, it is possible to retain in the final film the same pore structure as was in the precursor mesoporous  $\text{SiO}_2$  powder. Bare films calcined at 550° C. for 4 hours showed good hydrothermal stability. Since these films contain hierarchical porosity (i.e. both 35 Å pores and 0.1-0.5  $\mu\text{m}$  pores), and no "skin layer", permeability of these film is high, and these films are effective for analyte preconcentration of fluid analytes for enhanced spectroscopic analysis. While an exemplary embodiment of the present invention has been shown and described, it will be apparent to those skilled in the art that many changes and modifications may be made without departing from the invention in its true scope and broader aspects. The appended claims are therefore intended to cover all such changes and modifications as fall within the spirit and scope of the invention.

We claim:

1. A porous thin film, comprising:  
porous silica particles of at least one size below a preselected size threshold generally uniformly distributed and sintered together on a substrate, the film having a multimodal pore structure with a plurality of pore types that defines an open interface in the film, with large pores leading to small pores in each of the porous silica particles that provides for preconcentration of analytes therein.
2. The film of claim 1, wherein said particles have a surface area greater than 200  $\text{m}^2/\text{g}$ .
3. The film of claim 2, wherein greater than about 50% of said surface area is chemically accessible.
4. The film of claim 2, wherein said film has a thickness selected in the range from about 0.1  $\mu\text{m}$  to about 30  $\mu\text{m}$ .
5. The film of claim 2, wherein said film has a thickness selected in the range from about 0.3  $\mu\text{m}$  to about 30  $\mu\text{m}$ .
6. The method of claim 2, wherein said film has a thickness that is selectable in the range from 0.5  $\mu\text{m}$  to about 50  $\mu\text{m}$ .

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7. The film of claim 2, further comprising a preselected quantity of a preselected material selected from the group consisting of: a ceramic, a metal, an oxide, and combinations thereof.

8. The film of claim 1, further comprising a ligand operatively coupled to said particles selected from the group consisting of: thiols, carboxylates, sulfonates, phosphonates, amines, phosphines, ammonium salts, phosphonium salts, and combinations thereof, said ligand selectively binds to and concentrates a preselected analyte from a fluid in said film when contacted by said analyte.

9. The film of claim 1, wherein said uniform distribution of said film is obtained by a process of screen-printing.

10. A preconcentrator comprising a thin film, the preconcentrator characterized by:  
porous silica particles generally uniformly distributed on a substrate and sintered together in the thin film at a preselected thickness, the film has a multi-modal pore size distribution that defines an open interface, with large pores leading to small pores in each of the porous silica particles that provides for preconcentration of analytes therein.

11. A method for making a porous thin film, comprising the steps of:

- distributing a slurry comprising porous silica particles of at least one size below a preselected size threshold in a preselected solvent upon a substrate forming a generally uniform layer of a preselected thickness thereon;
- calcining the porous particles together to form a multimodal pore structure with a plurality of pore types that defines an open interface in the porous thin film, with large pores leading to small pores in each of the porous silica particles; and
- functionalizing the pores in the silica particles with preselected ligands that provide capture sites for preconcentration of analytes therein.

12. The method of claim 11, wherein the step of distributing said slurry to form a generally uniform layer is performed using a process selected from the group consisting of: screen-printing; web-coating; dip-coating; spraying; squeegee-ing; spreading; dusting; and combinations thereof.

13. The method of claim 12, wherein the step of distributing said slurry to form a generally uniform layer is performed using a screenprinting process.

14. The method of claim 13, wherein said screen-printing process that forms said generally uniform layer includes one or more screen-printing steps that provide a preselected film thickness.

15. The method of claim 13, wherein said screen-printing process includes use of a printing screen with a mil width selected in the range from about 0.2  $\mu\text{m}$  to about 1  $\mu\text{m}$ .

16. The method of claim 11, wherein said silica particles in said slurry are surfactant-templated mesoporous silica particles.

17. The method of claim 16, wherein said silica particles in said slurry are prepared by: precipitating said surfactant-templated mesoporous silica particles; milling said particles to a preselected size; and introducing said particles in a solvent or a mixture of solvents to form said slurry.

18. The method of claim 16, wherein the step of distributing said slurry includes use of a slurry prepared by: mixing a quantity of silicate particles of a preselected size with a binder in a solvent or a mixture of solvents that provides a preselected viscosity.

19. The method of claim 18, wherein said binder is an organic binder.