**FLUORINATED CYCLOALKENE**  
Functionalized Silicas

**BACKGROUND**

Fluorinated materials have been readily integrated into polymers, composites, and other functional materials for use in a wide range of applications, such as non-wetting, low-surface energy coatings. The use of fluorinated organic modified silicas over more conventional low-surface energy components, such as polytetrafluoroethylene, have shown to be advantageous due to the improvement in the fluorinated materials’ mechanical strength and durability. Types of fluorinated organic molecular and network silicas that have been employed for such purposes include polysilsesquioxanes, such as polyoctahedral silsesquioxanes (“POSS”), micro/nanometer-sized silica particles (e.g., micro silicas or nanosilicas), silica gels, and high surface area silica aerogels.

In addition to the improvement in mechanical properties, fluorinated organic modified silicas are highly desirable because of the unique combination of thermal stability, chemical resistance, low surface energy, low refractive index, and high insulating ability. Furthermore,
as nanometer-sized materials, these fluorinated organic modified silicas are compatible as fillers with organic polymers as the host matrix and can influence properties of organic systems making them highly attractive for the development of high performance, hybrid organic-inorganic materials.

Previous efforts to obtain fluorinated organic modified silicas have relied heavily on incorporating perfluorinated carbon chains into the periphery of the materials’ structure. Due to a heightened concern over the environmental impacts of perfluorinated carbon chains, there is growing need for alternatives that mitigate these fears whilst maintaining the desired properties. One conventional avenue for circumventing use of perfluorinated carbon chains is the implementation of fluorocyclic compounds, such as perfluorocyclobutane (“PFCB”) and perfluorocyclopentene (“PFCP”), especially in those silicas exceeding four continuous perfluorocarbon chains (e.g., 2:C6). The use of PFCB is becoming less common due to a number of factors, mainly because of the limited commercial-availability of the monomer derived from Halon 2402 (R-114B2, a fire suppressant).

In contrast, PFCP is readily available and is highly reactive towards nucleophiles, allowing for a wide variety of synthetic modifications. Yet, the use of PFCP for fluorinated organic modified silica compounds is yet to be fully exploited. Thus, there remains a need for fluorinated organic modified silica compounds and methods of synthesizing the same without evoking the environmental concerns associated with conventional methods.

INVENTION SUMMARY

This invention overcomes the foregoing problems and other shortcomings, drawbacks, and challenges of synthesizing fluorinated organic modified silica compounds without evoking the environmental concerns. While the invention will be described in connection with certain embodiments, it will be understood that the invention is not limited to these embodiments. To the contrary, this invention includes all alternatives, modifications, and equivalents as may be included within the spirit and scope of the present invention.

In accordance with an embodiment of the present invention, a fluorinated cyclopentene functionalized silica material is provided that comprises a silica material having a fluorinated cyclopentene moiety covalently bonded thereto. Exemplary silica materials include a polysilsesquioxane, a nanosilica, a microsilica, a silica gel, a silica aerogel, or combinations thereof. The fluorinated cyclopentene moiety is based on a modification of perfluorocyclopentene (i.e., 1,2,3,3,4,4,5,5-octafluoro-l-cyclopentene) by nucleophilic substitution with an appropriate nucleophile. In accordance with another embodiment of the present invention, a method for preparing fluorinated cyclopentene functionalized silica materials is also provided. For a better understanding of the invention, please review the entire patent for accompanying drawings, claims and detailed description.