Preface

"Sol–gel improves the quality of human life" says the masthead logo of the Israeli company (Sol-Gel Technologies Ltd) co-founded by the pioneer of sol–gel technology for obtaining molecularly doped silica glasses. Today indeed the millions of adolescents suffering from acne can finally treat the symptoms with sol–gel entrapped benzoyl peroxide without seeing their skin become further inflamed (Chapter 2). And if you think that *Acne vulgaris* is not a serious enough illness, now think of sol–gel entrapped cells of the *Taxus brevifolia* tree used to synthesize the powerful anticancer drug Taxol (Chapter 5); or consider the sol–gel entrapped cytochrome P450 enzymes at the basis of the MetaChip (Chapter 5) thanks to which compounds that merit further development as new drugs can be identified simultaneously and much faster than in the recent past.

Human life, furthermore, certainly benefits from a less polluted world, and here, again, sol–gel entrapped catalysts are, literally, able to have transferred to within their large inner porosity the whole chemistry of fine chemicals production. Think for instance of an innocuous easily handled orange powder called SiliaCat TEMPO (Chapter 5) that added to a mixture of alcohols at 0 °C with a modest excess of aqueous, cold bleach rapidly converts them into all those fragrances, vitamins, hormones and drugs made of carbonyl compounds.

And now think of the facade of a house painted with one of those new paints containing the sol–gel hybrid formulation recently commercialized by the world's largest chemical company (Chapter 4) that now will retain its fresh aspect for years.

Silica-Based Materials for Advanced Chemical Applications
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All of these—and the innumerable other—revolutionary applications that are finally reaching the market are obtained from a single class of materials, namely silicas and organically derivatized silicas.

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The hydrolytic polycondensation of silicon alkoxides of general formula $Si(OR)_4$ or $R'_nSi(OR)_{4-n}$, where the non-reactive organofunctional group R' acts as a network modifier, is carried out in the presence of dopant molecules resulting in the formation of highly porous, reactive organosilicates whose applications span many traditional domains of chemistry.

If R' can react with itself or additional components (R' contains vinyl, methacryl or epoxy groups, for example), the result of the condensation process is a flexible network of inorganic oxide covalently bonded to organic polymers, namely a hybrid nanocomposite lacking interface imperfections. The properties of this hybrid nanocomposite are intermediate between those of polymers and glasses, and can meet unique requirements.

First demonstrated by David Avnir in 1984, the principle is as simple as it is potent. Due to the low temperature needed for the preparation of sol–gel matrices, almost all of the 18 million existing organic and bioorganic molecules that could not be doped in glass, because glass is prepared at elevated temperatures (about 1000 °C), can now be entrapped in sol–gel glasses.

Organic chemistry and biochemistry have merged with the chemistry of ceramics.

Perhaps not surprisingly, at the same time as the doping methodology was being developed, researchers in Germany introduced a process which allows a precise control of hydrolysis and condensation rate of organosilicon and other metal alkoxides (such as those of aluminium, titanium and zirconium), which is the basis for making ORMOCER materials commercialized as protective hard coatings for transparent plastics since 1988.

When in 1994 the US and European patent offices recognized that the doped sol–gel technology had been invented by David Avnir and colleagues, granting the Hebrew University of Jerusalem a series of patents covering the generic methodology for the preparation of sol–gel materials, and their use in various applications, the time was ripe for the foundation of the first sol–gel chemical companies.

And indeed since then a large body of new companies has been established in countries as far from each other as Finland, Australia, the

USA, Italy and Germany. These have developed in-house, unique sol–gel processes to produce an arsenal of silica-based materials for drugs release and screening, catalysis, sensing, chromatography, *i.e.* addressing differing application needs.

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Writing a book in this burgeoning field runs two risks. The first is oversimplification, as there are entire volumes dedicated to single chapters of the present text (*e.g.* G. Kickelbick (ed.), *Hybrid Materials*, Wiley-VCH, 2006). The second is to produce another lengthy book aimed at disseminating research that, in the information overload era of the internet, would rapidly join all those ignored scientific texts (M. Reisz, Publish and be ignored, *The Times Higher Education*, 24 April 2008).

Instead, the aim is to provide a unified picture of the chemistry of functional silica gels. Hence, in place of a complete coverage of what has been done with these immensely versatile materials, an attempt is made to provide readers with an understanding of the principles behind the applications.

In other words, in the spirit of older scholarly publishing, the overall goal is to produce a readable, well-illustrated textbook in which elucidation of principles may ensure durability; and updated information on products, companies, markets and technology trends may render it a fresh reading.

Finally, publication of a book is inevitably linked to the times in which it is produced. And we are convinced that the present times are indeed right for such a book.

If the objectives have been achieved, then the book will not suffer from the obsolescence syndrome that makes a book outdated in the time lag between delivery of the manuscript to the publisher and the finished book's distribution.

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Finally, readers will not find a single chapter dedicated to biogels—silica gels entrapping biologicals—but rather specific examples of their usages in different fields. As the development of biotechnology is based on the immobilization of biomolecules or micro-organisms onto solid substrates, these materials—those already developed and those that are being created—are making a reality of biotechnology that has been awaited for many years (D. Avnir, T. Coradin, O. Lev and J. Livage, Recent bio-applications of sol–gel materials, *J. Mater. Chem.*, 2006, **16**, 1013). These materials deserve a thorough, consistent treatment that would exceed the scope of the present text.

This book should be useful to researchers and undergraduate students who carry out research in the field, and to managers and management consultants in the chemical industry who will gain a clear picture of what this technology is all about and how it can be used to solve their specific problems.

A section of my website (qualitas1998.net) features freely accessible additional teaching and communication materials (lecture slides, articles, links to companies and research groups, *etc.*). Readers are warmly invited to send their feedback: it will be used as a basis to improve future editions of the book.

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