Sol-gel materials

'Smart Petri dish' for tailored tissue growth

Robert Armon and Chen Zolkov from the Technion in Haifa, Israel and colleague David Avnir from the Hebrew University have developed hybrid sol-gel films that can be used in the place of conventional polystyrene Petri dishes for improved cell culture growth. The strength of this approach is its ability to produce a variety of surfaces by tailoring the properties of the sol-gel solution using dopants. The team say '*since these ceramic materials easily form composites with organic and bio-organic molecules and thus assimilate within them properties of those dopants, one gains all worlds: the inertness and durability of ceramics on one hand, and the ability to use the properties of any of the 22 million known organic molecules on the other hand*.'

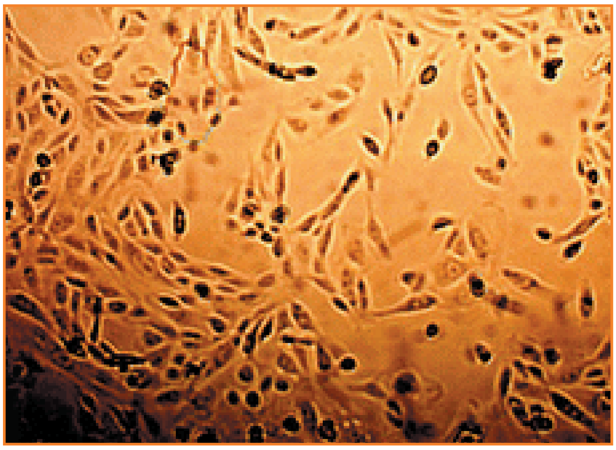

Figure 1: *Cell morphology and growth of tissue culture on sol-gel films.*

In their exploratory work, the team used buffalo green monkey kidney cells which are commonly used to grow and identify viruses in environmental samples. In a biological system cell growth requires a structured environment – an 'extra-cellular matrix' composed of a polymeric network of proteins and heteropolysaccharides. In an artificial environment, cell growth is dependent on the cells ability to anchor onto a solid surface. The properties of this surface can affect the degree of cell attachment and growth.

Armon and his group deposited a series of thin films on glass Petri dishes by forming sol-gel mixtures and then spin-coating these onto the glass surfaces. Films were made from pure silica, partially methylated silica and fully methylated silica, made by changing the volume rations of methyl trimethoxysilane and tetraethoxysilane in the sol-gel solution. Cells suspended in a growth medium containing fetal calf serum, were added to the differently coated dishes and the number of cells attaching to the dish surfaces were measured daily over 7 days using standard biological techniques. The cells were detached from the surface and then mixed with trypan blue stain which is used to distinguish viable from nonviable cells. The number of attached viable cells were counted under a microscope using a Neubauer haemocytometer – a specialised microscope slide with a grid imprinted on it to create a region of known volume.

Superior cell adhesion was gained with the partially methylated silica films, having intermediate hydrophobicity. The film made from 25% methyl trimethoxysilane performed the best. The success of these films shows that a mixture of hydrophobic and hydrophilic surface groups best facilitates cell adhesion and growth. The hydrophilic surface hydroxyl groups come from the silanols and the hydrophobic but lipophilic groups come from the methyls introduced into the films. These surfaces mirror the properties of cell membranes and the additional proteins found in growth mediums such as fibronectin that aid cell adhesion in nature.

In addition to the hydrophilic-lipophilic balance, Armon and co-workers also looked at the effects of surface charge. This was done by introducing a dopant into the sol-gel solution. A positively charged surface will bind to negatively charged sites on cell membranes and adhesive proteins so should improve cell growth. Experiments with doped methylated films using varying concentrations of poly-L-lysine (PLL) showed that indeed the presence of PLL as a dopant enhances cell attachment and growth.

The new biopolymer films created by Armon's group lead to a reduction in the amount of fetal calf serum needed for cell growth and adhesion in their modified Petri dishes. Reducing the use of serum is significant for several reasons. Serum is expensive and can introduce irreproducibility into experiments if different batches are used. In addition, the use of serum can lead to contamination of samples and the presence of additional factors from the serum may interfere with cell adhesion.

The new sol-gel films designed by the Israeli team give a versatile system for controlling and tailoring the properties of surfaces for tissue culture growth. The work carried out relates to the growth of one type of tissue, but it could be envisaged that other surfaces could be designed as needed - the group say; '*the main significance of our work is to show a convenient and versatile way to match the diverse needs of tissue-cell growth with a practically endless library of specifically tailored materials… in a sense, we have created a 'smart Petri dish*'. Their method is simple and the ability to trap different molecules within a sol-gel film as it forms gives a powerful and versatile tool for introducing any functionality. The study paves the way for further modifications in surface coatings of Petri dishes, perhaps leading to biotech and environmental large volume applications or for use in improving scaffold materials for tissue engineering and organ growth.

Tissue-derived cell growth on hybrid sol–gel films. Chen Zolkov, David Avnir and Robert Armon. *J Mater Chem.,* 2004, **14**, 2200 – 2205.

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