“Soft matter is ever pervading in the form of food, medicine, cleaning agents *etc.* impacting our day-to-day life in a variety of ways and we encounter them as plastic bags, toothpaste and shaving foam, the LCs in LCD screens, automotive lubricants, “slimy” biological materials, *etc.* It consists of a complex dispersion of minute particles in a liquid – a colloid. The particle in the colloid may be fine powder, polymer chain, surfactant micelle *etc.* with particle size ranging from nanometre to micrometer. Independent of the chemical nature of these particles, these complex soft materials follows some common physical behaviour which can be understood by simple laws of physics. It really matters how these complicated material behaves when subject to various external conditions. For instance some soft composite materials are known to change from liquid to gel-like solid, sometimes they become thinner when spread on a surface. These types of changes can pose challenges in their applications. Soft matter is not just all about chemistry and physics laws; the living cells which show similar strain and flow behaviour as polymers and surfactants can also be thought of as soft complex matter! It is no wonder then that researchers from different disciplines such as chemistry, physics, biophysics, *etc.* are fascinated by the complexity of soft matter research.
Dr Guruswamy Kumaraswamy, scientist at CSIR, National Chemical Laboratory (NCL), Pune has been investigating soft complex materials such as polymers, surfactants and colloids for the last fifteen years. He is a chemical engineer by training with a PhD from the California Institute of Technology, USA. His post-doctoral stint was at the Max Plank Institute for Colloids and Interfaces, Germany. His group mainly works on developing an understanding of how microstructure evolves in soft materials, to relate structure to properties; and to use this understanding to engineer application-oriented materials. This is important since understanding of these fundamentals can help in tuning the properties of a material e.g. generally polyethylene is an insulator, but if we tune the crystallization of this polymer it can become thermally conducting like metals. This and many such properties of polymers excite this polymer engineer and his group to try and control how the polymer crystallizes. For instance, his interest to control the degree of crystallization and the orientation of crystalline lamellae in semicrystalline polymers like polyethyleneoxide, so as to enable the polymer to be used as skin patches for drug delivery applications is a novel idea. Another exciting project currently ongoing in his laboratory is to synthesize ‘cubosomes’ made up of monoolein for drug delivery purpose. This has a speciality that it can be used to deliver a whole range of drugs that are hydrophilic as well as hydrophobic, without changing its phase behaviour. Further modifications of these unusual lipid assembly was made by using poly-ε lysine coating for targeting cells or using compact hydrophilic polyamine dendrons for self assembling the lipid particles to form suspended water droplets encapsulating hydrophilic drugs. Thus, it unveiled a surfactant-polymer complex for delivery of hydrophilic and hydrophobic compounds with sustained release; this is important because understanding this self assembly enables control of drug delivery.

Dr Guruswamy’s continued interest in biological systems has led his research group to explore the development of biliary stents or strictures. This helps avoid the operational complications involved in cancerous patients. Generally, in the last stages of cancer, infection to the sphincter of biliary duct necessitates its replacement by an artificial duct for the continued flow of bile to the stomach. These stents are of two types; self expanding and non-expanding. Self-expanding ducts are more convenient but are costly and unaffordable to common man. Dr. Guruswamy in collaboration with Dr. Sayam Sen Gupta and Dr. B.L.V. Prasad from NCL and with the help of a start-up company decided to contribute to this problem by developing non-clogging and self-expanding cheaper stents. Soft polymers and their interactions with biological system need to be explored for this kind of problems.
Imagine a certain material compresses to 100% and regains to its original size once pressure is released! This is the next exciting project in his group in which they have synthesized macroporous elastic composite scaffold using ice crystal templates. This involves colloid-surfactant interactions crucially carried at frozen state which produces materials that can sustain the compression to about 1/10th of their original size and repeatable over hundreds of times. One more feature of this material is that it maintains its elasticity even at 90% of inorganic material addition, whereas generally addition of inorganic material in polymers beyond 5% makes the polymer brittle. This phenomenon of ice crystal templated polymerization involving colloid particles has been successfully demonstrated for a wide variety of materials with various polymerization techniques provided the crosslinking occurred exclusively in the frozen state. This behaviour is very unusual and needs further exploration to understand the reasons for the same.

Above all these interesting projects, he handles some challenging industrial projects like solving the problem of softening of polyoxymethylene at temperatures much lower than its melting temperature (Tm). He could show that, this phenomenon was not intrinsic to the chemistry, but can be controlled by controlling the whole distribution of lamellar thicknesses thereby avoiding softening of the polymer below its Tm. This might indeed be a generic phenomenon, which is true for all semicrystalline polymers. This would imply that, rather than making complex structural changes, the problem could be addressed by some simple manipulations using additives to control the lamellar distribution. Dr. Guruswamy is also actively involved in technology development and consulting projects with various industries like led projects with General Electric, Procter and Gamble, Honeywell, Du Pont, General Cable, Reliance and Indian Oil Corporation (since 2002), etc.

With a research background like this where most of the people do not find time for social activities, Dr. Guruswamy balances both in parallel by various incentive programmes. One such programme is the “Exciting Science Group” in which scientists from various background delivers lectures and explains science in very fluid and simple language to school children.

Facilities available in his lab- SAXS, WAXS, optical microscope, Langmuir-Blodgett trough

**Small angle X-ray scattering (SAXS)**
Wide angle X-ray scattering (WAXS)
Polarized optical microscope

Langmuir-Blodgett trough