Base Line Data for Component 4

	ITEMS		Information
1.	Name of the consortium	:	Central Institute for Research on Cotton Technology, Mumbai
2.	Project code	:	C-2041 Synthesis and Characterization of Nano-Cellulose and its Application in Biodegradable Polymer Composites to Enhance Their Performance
3.	Project duration	:	July 9, 2008 to March 31, 2012.
4.	Present Area Activity Focus	:	Nanotechnology

5. Present status of science in the focus of proposed research:

Cellulose, a β-1,4 – linked high molecular weight polymer, is the most abundant organic molecule in the biosphere and central to plant morphogenesis and to many industries. It is now widely accepted that two crystalline phases coexist within native cellulose I, known as Iα and Iβ (Science, 1984, 223: 283-285). The highly crystalline purified grade of plant cellulose (alpha cellulose) is used as the raw material to produce microcrystalline cellulose (MCC). MCC has been widely used especially in food, cosmetic, and medical industries as a suspension stabilizer, a water-retainer and as a reinforcing agent for medical tablets. MCC obtained from different agricultural residues, namely, bagasse, rice straw, and cotton stalks bleached pulps were analyzed by M.El-Sakhawy and M.L. Hassan (Carbohydrate Polymers 67, 2007, 1-10) for their application in tablets. In spite of its vast applications, MCC scores low for use in composites and high strength applications, due to the presence of intervening amorphous regions (>15%) and low aspect ratio. At CERMAV-CNRS in France, nano-cellulose was prepared from wheat straw & tunicin and used as reinforcements in polymer matrices to increase the tensile strength (Angels & Dufresne, Macromolecules, 33, 2000, 8344-8353). About 30% increase in tensile strength of composites was observed when the MCC is replaced with nano-cellulose at 5% filler concentration. The advantages of nano-cellulose over MCC in composites are high crystalline region (>95%), reduced defects and high aspect ratio resulting in an increased interfacial interaction. Optimization of preparation of cellulose nanocrystals from MCC derived from Norway spruce (*Picea abies*) by concentrated sulphuric acid (64%) hydrolysis was carried out by Bondeson, Mathew & Oksman et al (Cellulose, 13, 2006, 171-180). Though the treatment of MCC with sulfuric acid gives isolated and stable nano-cellulose, the use of highly concentrated acid poses a threat to environment. Though exfoliated clay is explored widely for the preparation of nanocomposites, studies have shown that nano-cellulose imparts 10 times more tensile strength at the same per cent of filler concentration. Environment-friendly biocomposites were successfully developed using nano-cellulose as a filler to reinforce glycerol plasticized starch (Lu, Weng & Cao, Macromolecular Bioscience, 5, 2005, 1101-1107). This nano-cellulose was conventionally produced by concentrated sulfuric acid hydrolysis. These sort of reinforcements in polymers lead to improved mechanical strength and gas barrier properties. In cellulose nanocrystals reinforced poly oxyethylene, a thermal stabilization for temperature higher than the melting temperature of matrix was reported and ascribed to the formation of a rigid cellulosic network within the matrix and assumed to be governed by a percolation effect (Samir *et al*, Polymer, 45, 2004, 4149-4157). Highly compressed composites based on nano-scale fibrillated cellulose showed excellent mechanical properties, most strikingly in bending strength. The complete fibrillation of the fibres eliminated the weaker parts of the original fibre (Nakagaito & Yano, Appl. Phys. A, 2003).

In India, the research on cellulose from various biomass is mainly focused for its conversion to glucose and then to alcohol by a fermentation process. The cotton linters and other cellulosics are mainly utilized for the preparation of MCC and other cellulose

derivatives. Preparation and utilization of nano-cellulose is not yet explored in India. Since conventional petroleum based plastics pose an environmental challenge of a very large magnitude, the field of biodegradable products is emerging in India. Earthsoul India® is the India's first and only Internaltionally certified company which produces 100 percent biodegradable and compostable biopolymer products. Research work on biodegradable lignin-starch polymeric film (Trends Biomater. Artif. Organs, 2005, 18: 237-241), starch-based film and photodegradable polyolefin polymer and polyethylene polymer films is under way; however, these mulches have shown widely different rates of degradation. Though biodegradable mulches are still in the experimental stage, it will provide a huge breakthrough in reducing the cost of removal of plastic from the field eliminating the problem of its disposal.

6.	Expected output of the research	:	a) Appropriatly pretreated MCC suitable for hydrolysis by microbes and enzymes b) Celulose nanowhiskers production by *Trichoderma* sp. and anaerobic microbial consortium c) Cellulose nanowhiskers production by immobilized enzymes in membrane reactor d) Energy efficient chemo-mechanical process for production of cellulose nanofibrils e) Composites of nano-cellulose with biodegradable polymers f) Mechanical, barrier and biodegradability attributes of polymer nano-cellulose composites
7.	Present level of overseas exchange visit/training programmes (2007-08)	:	**CIRCOT**: Nil; **MUICT**: Nil
8.	Outcome variables i) Present level of number of publications in scientific journals annually (2007-08) ii) No. of applications for patents annually (2007-08) iii) Present level of number of technologies made available for commercialization annually (2007-08)	:	**CIRCOT** / **MUICT** 4 / 2 Nil / Nil 1 / Nil
9.	How the proposed research will open new vistas for a) Further scientific research	:	➢ In-depth understanding of the structural aspects of nano-cellulose and their interaction with magnetic nanoparticles ➢ Novel and eco-friendly enzymatic, microbial and chemo-mechanical protocols for preparation of nano-cellulose can be applied on other cellulose sources apart from cotton fibres ➢ Value addition to agricultural biomass like starch, cellulose and tamarind kernel powder by using them for preparation of biodegradable nanocomposites will result in extensive exploration on use of other available biopolymers

	b) Development of new technologies for commercial applications		➢ Large scale membrane reactors for preparation of cellulose nanowhiskers ➢ 100% biodegradable polymeric films with reduced oxygen and water vapour permeability to enhance quality for use as a packaging material and other uses
10.	Any environmental impact of present state of science and technology in your research problem focus that require to be set right	:	**Issues** / **Positive Impact** Release of harmful chemicals in the environment — Replacement of present chemical process by microbial and enzymatic processes will obviate the release of chemicals in the environment Plastics in the environment — Biodegradable plastics of high performance will be a great boon
11.	Any gender concern with existing state and technology in your research problem focus that needs to be set right (base line)	:	NIL

Place: Mumbai

Date: 14-1-2009

Dr. N. Vigneshwaran

Scientist (SS), CIRCOT, Mumbai.

Consortium Principal Investigator