5.5 SUMMARY AND OUTLOOK

Polymer nanocomposites that consist of a polymer matrix and homogeneously dispersed nano-sized fillers, have emerged over the past decade as the materials of choice for many applications due to their extraordinary mechanical and physical properties. Despite their unique features such as spherical shape, fine-tunable particle-size, surface amenable to desired functionalization and availability in various dispersions, the use of CS particles in composites is mainly limited to coating and thin-film applications, essentially due to the lack of thorough understanding on the influence of different factors including particle size, dispersing methodology and surface functionalization of the fillers on the improvement of overall performance of the resulting composites.

Fumed silica is the filler of the choice over CS while considering the preparation of reinforced composites, owing to both the relatively inferior reinforcing ability and the need for removal of dispersion medium once the composites are prepared in the case of CS. A limited understanding on the key parameters and hence the limited ability to control them also made the CS less favorable for making composites, in general. Given this, the preparation of CS based composites has been remained mainly of an academic interest, without any major commercially viable practical applications. With the growing interest in the PDMS based composites, it becomes imperative to investigate CS as the reinforcing filler in the PDMS matrix. The main aim of this work is to investigate the possibility of using CS as the reinforcing filler in PDMS composites.

This thesis details the preparation and the characterization of PDMS–CS composites, by taking into account of various key parameters. The various key parameters identified and investigated in the present study include, the size of CS particles, the loading of CS in the composites, the medium from which CS is dispersed into the PDMS matrix, the use of additional dispersing medium and the type of surface functionalization of CS particles. Thus prepared composites are characterized for their thermal and rheological characteristics in their uncured state and for their composition (FTIR analyses), morphological (TEM), optical (% T and % H) and mechanical (tensile strength, tensile modulus and % elongation) characteristics in the cured state. The
composition of CS particles, before and after functionalization, has also been obtained using different techniques including elemental and FTIR analyses.

The preparation of the PDMS composites with high levels of CS (> 50 wt %) while the typical loading of FS in the PDMS is only ~ 30 wt %, has been demonstrated in the present study. Despite the complex interactions prevalent among different key parameters, the present results clearly suggest the variation of competing particle-particle and particle-polymer interactions with the variation of key parameters. Since the commercially available CS dispersions are typically tailor-made to ensure the stable dispersion in the given dispersion medium and to achieve uniform dispersion of CS in a given polymer matrix, the judicious choice of CS dispersion for preparing the composites is critical. While making the choice we need to consider the functionalities already present on the surface of the CS particles, as they could influence the subsequent intended surface functionalization of CS while dispersing them into a resin matrix. Based on the various PDMS composites investigated in the present study, the following recommendations can be made;

1. The smaller size (15 ± 5 nm) CS particles are preferred among the different particle sizes investigated.

2. Among different trimethoxy silane based surface treatment agents investigated, methyltrimethoxy silane is preferred surface treatment agent;

3. The CS in methanol dispersion is preferred among the different CS dispersions investigated.

4. It is advantageous to use co-dispersant such as 1-methoxy-2-propanol to ensure uniform dispersion of CS within PDMS;

5. The use of 30-40 wt % FCS is preferred, though the choice of loading is typically application dependent.

As the present investigation is solely on the lab-scale experiments with a typical sample size of 50-100 g, further detailed optimization efforts are required for scale up operations involving the pilot plant and large scale manufacturing of PDMS-CS/FCS composites. Though the present study is pertained to the dispersion of CS/FCS within PDMS matrix in an optimal way, the conclusions derived from this study could
judiciously be extended to the preparation of the composites based on various polymers and fillers.

The results of present study not only provide various parameters that can influence the mechanical, rheological and optical properties; it also shows as how one can use CS with and without modification. Most importantly, there is a growing concern on the usage of nano powders due to their “unknown” effect on environment, especially human health. The use of nano-particulate dispersion, as investigated in detail in the present study can be considered as a viable alternative route to the use of nano powder, for making nano-composites, both in terms of its handling and its impact on the human health. The PDMS-CS composites of present investigation provide an incredibly large range of property profiles from which one can judiciously choose, depending on the cost (aqueous CS, CS in organic solvents without modification), the performance (optical and high mechanicals using specific organic sols with surface treatments) and the intended applications which include examples from different segments such as personal care, health care, construction, consumer, aerospace, automotive, electrical and electronics.