

CHAPTER 8

CONCLUSION

The main objective of the work reported in this thesis was to investigate interaction of organically modified silica nanoparticles (SiNP) and gold nanorods with some dyes of biomedical significance. SiNPs synthesized with 3 amino propyl and/or vinyl silica precursors and coated gold nanorods with their L-SP tuned to and away the absorption peaks of the dyes were used for the studies, while the dyes used were negatively charged polarity sensitive dyes (ANS, TNS and MC540) and photosensitizers (MC540, Cp_6 , PP18, MB and NB).

Photophysical studies on interaction of SiNPs with dyes ANS and TNS, showed significant shifts in the absorption and emission peak positions and enhancement in the fluorescence intensity of dyes in presence of the SiNP-VA in aqueous medium at physiological pH. The results obtained suggest that this was due to a strong electrostatic interaction between the positively charged SiNP-VA and the negatively charged dyes which lead to the suppression of the excited state charge transfer process in the dyes in presence of SiNP-VA, whereas it was absent in case of SiNP-V. This fluorescence was found to be pH dependent and decreased significantly after pH ~ 9.2 which is the pK_a of the amino propyl group. Therefore, this study shows that positively charged amino groups are present on the surface of SiNP-VA are at physiological pH, which is also confirmed by the Zeta potential measurements. In case of MC540 which is also a negatively charged dye, results of the photophysical studies suggest that the excited state photoisomerism process, which is the major non-radiative decay channel, is significantly suppressed due

to its binding to SiNP-VA. The observed enhancement in phototoxicity to cancer cells due to the dye-NP complex is consistent with the earlier observed enhanced singlet oxygen yield of the dye due to suppression of the excited state photoisomerism rate. Thus, these studies suggest that the interaction of SiNP-VA with negatively charged dyes is electrostatic in nature, which leads to significant changes in their excited state properties, suppressing non-radiative decay due to structural changes, enhancing their fluorescence properties and phototoxicity.

Our studies on the absorption and fluorescence properties of the photosensitizer Cp_6 in the presence of SiNP-VA indicated that the interaction is electrostatic in nature leading to significant changes in its acid-base equilibrium. Further, our studies showed that phototoxicity due to Cp_6 complexed to SiNP-VA, to cancer cell lines, was significantly higher as compared to free Cp_6 and was due to the enhanced photostability of the complex. We investigated the suitability of SiNPs as carriers of PP18 in aqueous medium at physiological pH. This was studied spectroscopically, by comparing its conversion to its hydrolytic product Cp_6 , among four nanoparticulate systems: SiNP-V, SiNP-VA, PLGA NP and Liposomes as its carrier. Our results showed that among these, SiNP-V is the most suitable carrier of PP18.

Interaction of negatively charged PSS coated gold nanorods and positively charged dyes MB and NB showed significant changes in the absorption and emission properties of the dyes. For both tuned and detuned cases, two absorption bands were shown in the 550-700 nm regions of the dye-AuNR complex. The high and low energy bands were attributed to the dimeric and monomeric species of the dyes for the detuned condition. However for the tuned condition (i.e. strong coupling regime) the interaction of the L-SP of the AuNRs with the dyes resulted in the formation of high and low energy bands whose splitting increased with increasing dye concentration and then saturated. This was attributed to arise from the coupling of L-SP band with the molecular absorption. Although the fluorescence intensity of the dyes in the presence of increasing

amount of PSS coated AuNRs were observed to be decreased the corresponding lifetimes were observed to increase. This was explained on the basis of the formation of nonfluorescent dimeric species, suppression of the excited state nonradiative decay channels and the influence of the L-SP field.

We also investigated binding of Cp_6 with CTAB, PAH and PDDAC coated rods. Due to binding, while the fluorescence intensity of Cp_6 decreased significantly in all the rods, the lifetime decreased significantly only for the CTAB coated rods. While, the polymer (PDDAC & PAH) coatings affected only the radiative rates of the drug, for CTAB coating, both radiative and nonradiative rates decreased significantly. The observed quenching of Cp_6 fluorescence in the presence of CTAB coated AuNRs was attributed to both, a decrease in the transition probability for radiative transitions and to energy transfer. This is suggested to be due to the difference in the distance between the Cp_6 and the gold surface of the rods, the distance being small in case of CTAB coated rods, due to single layer of CTAB coating, while there are two more coatings, PSS and PDDAC/PAH, in case of PAH and PDDAC coated rods which could prevent energy transfer. Another interesting result was that among the PAH and PDDAC coated rods, a significantly large decrease in quantum yield in presence of PAH coated rods as compared to PDDAC was observed. This has been attributed to the difference in the chemical structures of the two polymers. The photostability of Cp_6 bound to CTAB and PAH coated rods was found to be more as compared to PDDAC coated rods and free Cp_6 which suggests that it also depends upon the nature of the coated material. This study shows that CTAB and PAH coatings may be preferable while utilizing these rods for combined hyperthermia and photodynamic therapy applications.

The results of our studies presented in this thesis show that the conjugation of the photosensitizers with NPs changes their photophysical properties. Since this also affects their biological activity, it is suggested that a thorough study of the photophysical

properties of the photosensitizers conjugated to the NPs should be carried out before using such formulations for therapeutic applications.