# CONCLUSIONS AND SCOPE FOR FUTURE WORK

## Conclusions

- An attempt was made to prepare modified chitosan adsorbents CD and CTMA using DTPA and TMA by ionic cross linking for removal of chromium. The formation of ionic cross linked polymers was established by IR, Raman and XPS techniques.
- Futhermore, Chtosan was also modified with layered zirconium phosphate to form CZrP and was used as adsorbent wherein ZrP in nano form was prepared in autoclave. The Zrp was found to have some $Zr^{3+}$ ions due to the radicals formed in autoclave as evidenced by ESR and XPS techniques .
- Nano sized Polyaniline was also prepared and its potential for removal of chromium was reinvestigated
- The adsorption process followed 2nd order kinetics and Langmuir isotherm model indicating monolayer adsorption for CD, CTMA and CZrP. The adsorption process with polyaniline was found to fit Freundlich isotherm and pseudo 2nd order kinetic models.
- The mechanism of adsorption was found to be adsorption by Electrostatic attraction and Hydrogen bonding followed by reduction for CD and CTMA. The mechanism of adsorption process for CZrP was found to be adsorption by ion exchange and hydrogen bonding followed by reduction by chitosan and further binding of $Cr^{3+}$ to the adsorbent. The mechanism of adsorption for PANI was found to be adsorption by electrostatic attraction followed by reduction
- To the best of our knowledge there are no reports on the use of ionic cross linked polymers as adsorbents with chitosan and nano zirconium phosphate with $Zr^{3+}$ ions as defects. When the prepared ZrP was incorporated into chitosan matrix rod shaped nano ZrP was seen to be formed along with regular hexagonal shaped ones. The rod shaped NPs were not seen in the TEM of pristine ZrP
- The prepared adsorbents had good adsorption capacities in comparison to earlier reported ones as summarized in Appendix.
- Other polyamino carboxylic acids could be used for modification of chitosan and their potential for removal of lead, chromium and iron could be investigated.

- The adsorbents could be successfully used for the removal of chromium from chrome plating effluent. It was observed that CD and CTMA showed good potential for the removal of lead and iron too. The adsorbents could be used for the removal of iron from natural waters
- Further it was our objective to prepare DTPA capped nano Ag and Au NPS and use them for sensing chromium. The nanoparticles in solution form were prepared successfully by using green process by providing thermal energy in the form of microwaves and by using green capping agent DTPA. The formed NPs were characterised by their characteristic SPR and Raman spectroscopy. The AuNPS were found to have good stability while AgNPS were stable for a week.
- The prepared NPs could be successfully used for sensing both $Cr^{3+}$ and $Cr^{6+}$ without requiring any interconversion from one form to another with reasonably good detection limits

**Scope of future work**

- Adsorption and sensing being thrust areas of research in environmental chemistry, tremendous amount of work is being undertaken by researchers across the globe. This has led to a vast amount of literature. Though we have tried to cite all relevant literature to the context literature quoted in the thesis is not exhaustive due to space constraints.
- More insights about the adsorption process would be obtained if three parameter isotherms like Redlich Peterson were investigated.
- CD and CTMA could be investigated as adsorbents for lead and iron..
- It would be of interest to investigate the preparation of uniform rod shaped nano ZrPs using chitosan as matrix.
- During the course of our work in the use of AgDTPA and AuDTPA NPs as colorimetric sensors for $Cr^{3+}$ and $Cr^{6+}$ we did not try to investigate whether total chromium ($Cr^{3+}$ and $Cr^{6+}$) could be determined. Efforts in this direction would be useful.