Chapter 7

Conclusion and future scope

7.1 Conclusion

Vegetable oils are environment friendly as they are biodegradable in nature. Moreover, they are available worldwide and have many other social and economic advantages. *Jatropha curcas* with its many attributes has drawn special attention to the scientific community. Different parts of the crop have considerable potential in various uses. The oil has been utilized in a wide variety of industrial applications. Alkyd resins with the versatile properties such as solvent-free, ease of application, recyclable, less waste production, low cost, and biodegradable nature give them an altitude above the other vegetable oil derivatives. In addition, the presence of reactive functionalities like double bonds, hydroxyl groups, carboxyl groups, and ester linkages facilitate a large number of modifications to achieve desired level of properties.

The main objective of the present thesis is to develop alkyd resins based on *Jatropha curcas* oil and to explore its potential in the field of polymer science. Different techniques have been developed, including blending and nanocomposite decoration, in order to get alkyd based coatings with desired properties. A chapter of the thesis is devoted to develop vegetable oil (soybean oil) based polymer networks and their *green* bionanocomposites. The important findings of the present investigation are summarized chapter wise below:

Synthesis, characterization, and performance characteristics of *Jatropha curcas* oil based alkyd resins and their blends with epoxy resins

- Jatropha oil with semi drying nature is a suitable candidate for the preparation of alkyd resins.
- Kinetic study of alkyd resin preparation showed that the polyesterification reaction followed a second order rate law and the rate constant was found in the order of 10^{-4} g (mg KOH)$^{-1}$ min^{-1}.
- An appreciable degree of conversion was noticed from the extent of reaction. The extent of reaction increases with increasing PA content in the resins and lies in the range of 52.4-61.2%.

- The curing characteristics of the jatropha oil modified alkyd resins can be improved by blending with a fast drying epoxy resin.
- The performance characteristics such as gloss, adhesion, flexibility, hardness, and chemical resistance of the alkyd resins suitable for use in surface coating applications.
- The alkyd/epoxy blends exhibit very good thermal stability (>250 °C) and tensile properties (22.7 MPa).

Blends of epoxidized alkyd resins based on jatropha oil and the epoxidized oil cured with aqueous citric acid solution: A green technology approach

- Jatropha oil based alkyd resins can be cured by bio-based polymer networks of EJO and aqueous citric acid solution.
- Epoxidation of the alkyd resins facilitated the cross-linking reactions with EJO in the presence of citric acid.
- The curing time, thermal stability, and mechanical properties of the alkyd resins were improved significantly on blending with EJO.
- The technique used here offers a number of advantages, including environmentally friendly, low cost, easy performance, solvent-free/catalyst-free, and bio-based content, opening a number of opportunities in the paint industries.
- In addition, the thermal and mechanical properties of the films can be improved further by postcuring at 160 °C.
- The molecular rearrangements produced by thermally activated transesterification reactions of −OH groups generated in the ring opening polymerization reaction with residual −COOH groups resulted in increased cross-linking density of the polymer networks during postcuring.

Jatropha curcas **oil based alkyd/epoxy resin/expanded graphite (EG) reinforced bio-composite: Evaluation of the thermal, mechanical, and flame retardant properties**

- EG is an effective filler to impart superior performance characteristics to the alkyd/epoxy resin matrix.

- The thermal stability of oil modified polymer matrix increased significantly by the decoration of composite structure.
- The homogeneous dispersion and strong interfacial adhesion of polymer matrix and EG platelets facilitates efficient load transfer from the polymer matrix to the fillers.
- The alkyd/epoxy/EG biocomposites exhibited very low water absorption and PBS degradability.
- The flame retardant property of the polymer matrix improved significantly by the incorporation of EG.

Jatropha curcas oil based alkyd/epoxy/graphene oxide (GO) bionanocomposites: Effect of GO on curing, mechanical, and thermal properties

- Jatropha oil modified alkyd resins and GO based bionanocomposites were prepared successfully by solution intercalation method.
- GO significantly accelerates the curing rate of the alkyd/epoxy blends.
- XRD and TEM study revealed the formation of highly exfoliated structures and the homogeneous distribution of GO nano-sheets within the polymer matrix.
- Homogeneous dispersion and strong interfacial adhesion of GO with the polymer matrix significantly improved the thermo-mechanical properties of the bionanocomposites.
- The thermal stability of the bionanocomposites increased upto 39 °C by the incorporation of GO.
- The tensile strength and elastic modulus of the alkyd/epoxy/GO bionanocomposites increased by 133% and 68%, respectively.

In situ synthesis of green bionanocomposites based on aqueous citric acid cured epoxidized soybean oil-carboxylic acid functionalized MWCNTs

- The study revealed a class of *green* bionanocomposites which was prepared by an *in situ* solvent free and catalyst free method.
- Citric acid, which is produced at large scale from citrus fruits, is an effective curing agent for the epoxy resins.

- The bionanocomposites with high bio-based content exhibited impressive performance characteristics.
- The bionanocomposites are thermally stable upto 327 °C and can be improved further upto 343 °C by postcuring at 160 °C for 10h.
- The strong H-bonding and covalent interactions of the c-MWCNTs with the ESO-CA polymer networks resulted in improved performance characteristics of the bionanocomposites.
- The molecular rearrangement produced by thermally activated transesterification reaction of -OH groups with residual -COOH groups on postcuring stage resulted increase in cross-linking density of the polymer networks. However, the effect was more pronounced with the high concentration of c-MWCNTs in the bionanocomposites.

7.2 Future prospects of the present investigation

Although a large number of works have been done on jatropha oil modified alkyd resins, still there are many scopes in this field to investigate. For instance,

- Development of UV-curable alkyd coatings.
- Exploration of flame retardant alkyd resins.
- To investigate alkyd-acrylate co-polymers to get resins with better curing and mechanical performances.
- To develop corrosion resistance alkyd coatings.
- Functionalization of the vegetable oils to produce value added diverse products.
- To decorate functional bionanocomposites based on the vegetable oil derived polymer networks.