The important results obtained from the present investigation are summarized and given below.

TiO$_2$ thin films have been prepared by sol–gel dip coating method. The prepared films were annealed at three different temperatures 400°C, 450°C and 500°C respectively.

The structural studies carried out on the annealed TiO$_2$ films indicated that the films are nanocrystalline in nature with grain size around 28nm for 500°C annealed film. The films exhibited anatase phase. The anatase phase has been identified using x-ray diffraction method and confirmed using HRTEM images and Raman analysis. The surface morphology of the prepared films has been studied by using emission scanning electron microscope. The atomic force microscope images of the TiO$_2$ thin films show well-defined particle-like features and indicates the presence of small crystalline grains. The optical band gap has been observed to lie in the range of 3.73 to 3.61eV. The optical band gap has been observed to decrease with increase in annealing temperature. The photoluminescence studies have indicated the presence of defect levels leading to luminescence. The dip coated TiO$_2$ films is made up of interconnected small grains forming a mesoporous nanocrystalline semiconductor with a wide band gap suitable for the incorporation of dye for solar cell applications.
For the dye extract preparation, flowers of blue pea, red rose, table rose, red cabbage and leaves of solanum nigrum and eclipta alba were well cleaned and mixed with 100 ml ethanol and were kept for 12 hours at room temperature. Then residual parts were removed by filtration. This solution was directly used as dye solution for sensitizing TiO$_2$ electrodes. The intensity of light absorption has been enhanced due to the interfacial Ti–O coupling between the dye molecules and the TiO$_2$ molecule. It is generally accepted that the chemical adsorption of these dye takes place due to the condensation of alcoholic-bound protons with the hydroxyl and carboxyl groups present on the surface of the nano structured TiO$_2$ thin films. This chemical attachment affects the energy levels of the highest occupied molecular level (HOMO) and the lowest unoccupied molecular level (LUMO) of the dye molecule which eventually affects the band gap of these materials and this results in a shift in the absorption band of the absorption spectra.

The structure of the fabricated type solar cell is ITO/TiO$_2$/dye/Pt electrode. The red cabbage dye extract sensitized TiO$_2$ solar cell exhibited a power conversion efficiency of 0.73 % with a short circuit current density ($J_{sc}$) of 4.38 mA/cm$^2$, open circuit voltage ($V_{oc}$) of 0.47 V and fill factor (FF) of 0.36. The blue pea dye extract sensitized TiO$_2$ solar cell exhibited a power conversion efficiency of 0.67 % with a short circuit current density ($J_{sc}$) of 4.16 mA/cm$^2$, open circuit voltage ($V_{oc}$) of 0.45 V and fill factor (FF) of 0.35.

The red rose dye extract sensitized TiO$_2$ solar cell exhibited a power conversion efficiency of 0.81 %, with a short circuit current density ($J_{sc}$) of 4.57 mA/cm$^2$, open circuit voltage ($V_{oc}$) of 0.485 V and fill factor (FF) of 0.36. The table rose dye extract sensitized TiO$_2$ solar cell exhibited a power conversion efficiency of 0.67 % with a short circuit current density ($J_{sc}$) of 4.23 mA/cm$^2$, open circuit voltage ($V_{oc}$) of 0.46 V and fill factor (FF) of 0.35.
The solanum nigrum dye extract sensitized TiO$_2$ solar cell exhibited a power conversion efficiency of 0.77 % with a short circuit current density ($J_{sc}$) of 4.46 mA/cm$^2$, open circuit voltage ($V_{oc}$) of 0.48 V and fill factor (FF) of 0.36. The eclipta alba dye extract sensitized TiO$_2$ solar cell exhibited a power conversion efficiency of 0.60 % with a short circuit current density ($J_{sc}$) of 4.04 mA/cm$^2$, open circuit voltage ($V_{oc}$) of 0.43 V and fill factor (FF) of 0.34.

Although the efficiencies obtained with these natural dyes are still below the current requirements for large scale practical applications, the results are encouraging and may initiate additional studies oriented towards the surface modification of TiO$_2$ films and be an inspiration for the search of new natural sensitizers. Even though the efficiencies obtained are not comparable with the efficiencies of commercial solar cells, the study shows the potential of natural dye to be used as sensitizers, and may be an initiative for more focused research in this direction. Extraction of natural dyes with suitable solvents and using them for solar cell applications may pave way for the improvement of efficiency. Preparation of high surface area nano particles with improved carrier transport properties will certainly improve the performance of the cells and hence is suggested for future work.