Vertebrate body contains both soft and hard tissues to carry out life processes. Among the hard tissues horn, hoof, feather, claw and nail are the derivatives of the skin. Generally, skin is known as integument. However, the hard tissues, which serve as exoskeleton, can also be referred as integuments as they are highly useful in protecting the body from the environmental influences, acting as thermo-insulators and thermo-regulators.

In nail, the dorsal unguis is brought and flattened while the subunguis is reduced to a small remnant, which lies under the tip of the nail. The root of the nail is the place of growth of the unguis and lies embedded in a pocket under the skin called the nail groove or sulcus unguis. The nail bed lies beneath both the nail and its root. The proximal part or matrix is the most important and is concerned in the formation of the nail. Its anterior portion in man may be seen through the base of the transparent thumbnail and forms the whitish lunula, the crescent shaped area. The stratum germinativum above the base of the nail forms a rather rough margin where the nail emerges from the sulcus unguis.

As far as organic matter is concerned, the major portion of the nail is made up of albuminoid proteins called keratins. These fibrous proteins are characterized by their very high insolubility in usual protein solvents, because of high sulphur content, which is in the form of cystine.

Indeed, biologists have developed specific areas like anatomy, physiology and biochemistry of the calcified tissues, and valuable treatises have been presented as a result of these studies. But no
attention is paid to make systematic investigations on solid state properties of the keratinous hard tissue material such as nail.

In view of the above facts an attempt has been made to study molecular composition cellular assembly and solid state properties of keratinous hard tissue - the nail belonging to different age and physiological condition of the man.

The thesis contains 7 chapters.

1. Introduction.
2. Energy dispersive X-ray analysis of human nail
3. Scanning electron microscopy of human nail
4. Infrared spectroscopic analysis of human nail
5. X-ray diffractrometric studies on human nail
6. Growth rate and density of human nail
7. Electronic properties of human nail

Chapter 1 is concerned with the introduction of the integumentary system which consists of skin and its derivatives (Sweat and oil glands; hairs; and nails). The morphology, biochemistry, chemical composition structure of human fingernail is explained on which the detailed studies are made.

The development of integumentary system; physics and chemistry of the human nail are highlighted for the study of physical parameters and to understand the organic and inorganic composition of the human nail. This information is very much essential to a biophysicist whose main interest lies in understanding the biological complexity of living system by the application of principles of physics. A search of literature reveals that a broad investigation has been made on the chemical properties of biological macromolecules, cells, tissues of human nail. But no detailed information is available on solid state properties of human
nail. In view of this, in the present investigation, studies on the solid state properties have been made on male and female human fingernail.

Chapter 2 is concerned with the organic and inorganic composition of male and female human nail. Energy dispersive X-ray analysis is employed to study the percentage of elements. Biological molecules are built up elements C, O, Na, Mg, Al, Si, P, S, Cl, Ca, and K. The carbon isotopes of human nails give dietary information related to both food sources and dietary practices in a region. The increasing carbon content with ongoing age could be explained by loss of inorganic material from the nails, followed by a subsequent increase of organic materials. The higher concentration of Cl, Na and K, found in human nail, leads to a disease known as cystic fibrosis. Percentage of Al increasing with age indicates the hardening of human nail. The brittleness of human nail depends on amount of Si. Human nail exposed to harmful substances will decrease the level of sulphur by the diminution of sulfur proteins in the nails leads to structural abnormalities in the nail. The variation in the percentage of elements leads to human nail disorder.

Chapter 3 is dealt with the structure of various micro molecular components and their conformation within the tissue. Scanning electron microscopy is employed to study the structural micro molecular components of human nail. The important aspects related to keratinised hard biomaterial tissue is the morphology of human nail. Scanning electron microscopy is the best technique to study the structure and arrangement of proteins in the human nails. This technique gives the qualitative information rather than the quantitative. One can visualise the happenings of the tissue.

The scanning electron micrographs of human nail reveal three nail layers – upper (dorsal), middle (intermediate) and lower (ventral). The
Chapter 4 is concerned with the infrared spectroscopy of human finger nail. Infrared spectroscopy is employed to study the human nail. Infrared absorption spectrum is used for the identification and analysis of different chemical combinations in the material system. The quantitative analysis is also possible by IR spectroscopy due to the fact that absorption of radiation at various infrared frequencies is quantitatively related to the number of absorbing molecules in a system. In specific cases, infrared spectroscopy affords rapid qualitative and quantitative identification of organic and inorganic constituents and their combinations in mineralized tissues such as bones, calculi, gall stones and human nails.

Bands are observed in the entire spectrum from 4000 to 400 cm$^{-1}$ for both male and female human nail. Their vibrational classification is N$\cdash$H stretching, C$\cdash$H stretching, C = O stretching, C = C stretching, N$\cdash$H bending, C-O-C stretching, C-O stretching, O-H bending, C-O stretching and bending. The bands observed at 603.89 cm$^{-1}$, 693.17 cm$^{-1}$, 666.43 cm$^{-1}$ indicate the presence of water in human nail. It is interesting to note that the bands 470 cm$^{-1}$,560cm$^{-1}$ and 960cm$^{-1}$ characteristics of calcium phosphate are not found in IR spectra of human finger nail.

Chapter 5 presents the analysis of X-ray diffraction of human finger nail. Of all the methods available to the analytical chemist only X-ray diffraction is capable of providing general purpose qualitative and quantitative information on the presence of phases i.e., compounds in an unknown mixture. The method is applicable to almost any crystalline
material, whether inorganic or organic. The broad peaks in x-ray diffractogram of human male and female finger nail reveals that no crystalline material, whether it is inorganic or organic is present in the human finger nail.

Chapter 6 is concerned with the growth rate of male and female human nail. Simple equipment known as digital vernier callipers is used to measure the growth. It is interesting to note from the nail growth graphs that initially growth of nail is low in males when compared to that of female and finally it comes to the same in both the sex. The comparison of the data on mean growth rate (mm/day) shows the most striking feature that the mean growth rate (mm/day) increases rapidly up to 1 – 2 weeks and then it decreases in both male and female subjects. The average value along with S.D. of density of male human nail is $4.582 \pm 1.887 \text{ gm/cm}^3$, while in the case of female human nail it is $4.425 \pm 1.999 \text{ gm/cm}^3$.

It is known that nail becomes more pliable and bulky when soaked in water and changes to brittle when it is dried. Hence, the significant variation in density of different nail sample, as revealed by S.D., can be attributed to large variation in water content of the nail.

The thesis ends with the chapter 7, which deals with the electronic properties of male and female human nail such as V-I characteristics, resistivity and activation energy. The study of the electronic properties of biomacromolecules should, therefore, become part of the interdisciplinary armory of the biological sciences. Advances in such studies should certainly be of benefit to some branches of medicine. From the voltage – current characteristics of human nail, it is obvious that human nail shows ohmic behaviour. Electrical resistivity of male and female human nail is calculated by measuring resistance, thickness
and contact area of the sample. The mean value of electrical resistivity is $297.7 \pm 64.1215 \ \text{G}\Omega\cdot\text{cm}$ in males, while it is $431.87 \pm 100.1277 \ \text{G}\Omega\cdot\text{cm}$ in females. The significantly large variation in electrical resistivity of human nail irrespective of gender can rarely be attributed to the water content as human nail is very sensitivity to the absorption or release of water. As is known, the energy gap of a material can be considered as the index for the characterization of materials as conductor, semi-conductor and insulator. The mean values of energy gap of male and female human nail are $0.2735 \pm 0.0529 \ \text{eV}$ and $0.2565 \pm 0.0349 \ \text{eV}$ respectively, which are in the range of semiconductors. One of the interesting aspects is that the resistivity of female finger nail is higher than that of male. Human nail is an insulator due to its high resistivity. On the other hand human nail is semiconductor possessing activation energy in the range of electronic semi conducting material.