CHAPTER 2

SYNTHESIS OF ELECTROSPUN ZnO / CuO
NANOCOMPOSITE FIBERS AND THEIR DIELECTRIC,
AC CONDUCTIVITY AND NON-LINEAR
OPTICAL STUDIES

2.1 INTRODUCTION

In recent years, nanomaterials research has gained greater
momentum due to their possession of enthralling magnetic (Farghali et al
2010, Deraz 2010), optic (Li et al 2009, Xiaorui Hou et al 2010), catalytic,
thermoelectric and mechanical properties (Li-Dong Zhao et al 2008).
Numerous methods have been recommended for the synthesis of such
materials including mechanical alloying (Azizi and Sadrnezhaad 2009),
sol-gel process (Deyi Wang et al 2009), chemical vapour deposition (CVD)
(Escobar et al 2010), microwave synthesis (Chung-Hsin Lu et al 2009),
Metal-Organic CVD technique (MOCVD) (Capula Colindres et al 2009),
co-precipitation method (Xiaorui Hou et al 2010), facile route synthesis
approach (Li et al 2009) and electrospinning process (Avinash Baji et al
2011). One dimensional nanoscale materials like nanofibers, nanowires,
nanorods and nanotubes have attracted superior concentration among
researchers because of their potential scientific and technological applications
owing to their large surface area per unit mass, smaller pore size and low
Recently, electrospun camphorsulfonic acid doped poly (o-toluidine)–polystyrene composite fibers were used effectively as chemical vapor sensors (Aussawasathien et al 2008). Electrical and photovoltaic properties of cobalt doped zinc oxide nanofibers/n-silicon diode were studied by Fahrettin Yakuphanoglu (2010). Carbon nanofiber /LiFePO4 composites were effectively used as lithium batteries (Bhuvaneswari et al 2008). Electrospun carbon/CdS coaxial nanofibers were found to exhibit photoluminescence and conductive properties (Yang Yang et al 2007). Due to the electrochemical characteristics of activated carbon nanofibers, they are used as electrodes for super capacitors (Min-Kang Seo and Soo-Jin Park 2009). Nanocomposite materials are desirable due to their compliant nature in the design of prolific electronic devices (Sun-Dong Kim et al 2006, Mekprasart et al 2010, Sun Kyu Kim et al 2010). Several novel nanofibers such as ZnO/SnO2 (Ruilai Liu et al 2010a), Nickel/Carbon (Jian Li et al 2009), TiO2 (Jianguo Zhao et al 2008), NiO (Hongyu Guan et al 2003a), copper oxide (Hongyu Guan et al 2003) and ZnO/ZnS (Yong Liu et al 2006) have been successfully synthesized by the twinning of sol-gel and electrospinning processes. Synthesis of ZnO nanofibers by using the electrospinning process has been studied by Siddheswaran et al (2006).

Zinc oxide (ZnO) is a wide band gap II – VI semiconductor with a band gap of 3.37 eV. It has a large exciton binding energy of 60 meV (Manjula G. Nair et al 2011). These oxide semiconductors have many advantages. Due to their wide band gap, they are transparent and also suit well in applications with short wavelength. They can be easily grown at low temperature into any form and are ecologically safe and durable besides being low in cost.

ZnO is a semiconductor material of II-VI compound of the periodic table whose ionic nature resides at the borderline between covalent and ionic
semiconductor. The electronegative difference between zinc and oxygen produce a high degree of ionic nature in its bond. Because of the repulsion of its electronic clouds of charge, the more stable electronic structure of ZnO is wurtzite. In this structure, the atoms are completely remote to be able to compensate this repulsion. Thus, each atoms of Zinc is surrounded by four cations of oxygen at the corners of a tetrahedron and vice versa. This tetrahedral coordination is typical of sp\(^3\) covalent bonding and possesses substantial ionic character. This crystalline structure is known as wurtzite structure and has a hexagonal unit cell.

Zinc oxide is a very good optical and non-linear optic (NLO) material. The NLO properties such as second harmonic generation and third harmonic generation have been studied by several researchers (Kulyk et al 2009, Vijaya Prakash et al 2008). Zinc oxide has been effectively used as luminescent materials, gas sensors and solar cells. Zinc oxide has been efficiently tested for its sensing of various gases such as NO\(_x\), H\(_2\), O\(_2\) and ethanol (Hussain et al 2010).

Nanometer-sized semiconductor materials have been studied intensively since they exhibit large optical nonlinearity and fast response time due to their novel electronic structures originated from quantum-confined effect and interfacial effect (Tingyin Ning et al 2009). Second-harmonic generation and multi photon induced photoluminescence in ZnO has been studied by Noh Soo Han et al (2009). Nonlinear optical properties of ZnO nanorods were studied by Soon-Ki Min et al (2009).Third order NLO response has been studied in ZnO photonic structures by Vijaya Prakash et al (2008). ZnO nanorod arrays on textured nanoparticle nanoribbons and its second-harmonic generation performance has been investigated by Zhou Gui et al (2006). The second and third harmonic
response of ZnO films with copper dopant have been studied by Kulyk et al (2009).

Copper oxide (CuO) is a narrow band gap semiconductor material. It possesses unique physical properties and great potential for diverse electronic and photonic applications (Padyath et al 1994). Second harmonic generation of the oxidation of copper electrodes has been investigated by Shah M.A. Baten et al (2007) and Hewitt et al (1993). Nano-confined and copper defect in wide-band gap semiconductors have been studied by Idrish Miah (2011). Third order NLO properties of CuO thin films have been studied by Aiping Chen et al (2009). Copper oxide is used as gas sensor, magnetic storage media and solar panels (Dar et al 2009).

In the present work, ZnO/CuO nanofibers were synthesized and characterized by powder XRD, SEM, AFM, FTIR, EDAX, UV and their dielectric and non linear optical properties have been studied.

2.2 EXPERIMENTAL STUDIES

2.2.1 Preparation of PVA / copper acetate / zinc acetate composite sol

Poly (vinyl alcohol) (M. W = 1, 25, 000 g/mol) with high purity, zinc acetate dihydrate extra pure and copper acetate purchased from Merck (99 % purity) were used without further purification. Deionised water was used as solvent.

1.2 g of copper acetate was dissolved in 10 mL of deionised water and added to 30 g aqueous PVA solution (about 10 wt %) with constant stirring at 333 K for one hour. 10 mL of deionised water was added to 1.2 g of zinc acetate and then slowly added into the already prepared copper acetate / PVA solution. To this solution, 6 mL of ethanol and 0.5 mL of acetic acid
were added while stirring. Acetic acid prevents precipitation and acts as hydrolysis/condensation catalyst. The above prepared solution was stirred for 6 h keeping in a water bath maintained at 323 K. A viscous, clear sol solution of PVA / zinc acetate / copper acetate was obtained and used in the electrospinning process.

### 2.2.2 Preparation of Nanofibers

The electrospinning apparatus consists of a hypodermic needle filled with 2 mL of precursor PVA/ zinc acetate / copper acetate composite viscous sol gel solution. The temperature of the sol was maintained at a constant temperature of 303 K. The metallic tip of hypodermic syringe needle with an opening of 27 gauge was connected to the positive terminal of the high voltage DC generator (5 to 40 kV) and the negative of the generator was connected to a grounded collector. The aluminium sheet which is used to collect the nanofibers was fastened to the grounded metal plate by using a double-sided tape. By applying a high potential difference between the terminals, the positively charged gel is ejected from the syringe due to the attraction from the oppositely charged target, resulting in a jet. Whenever the applied voltage overcomes the surface tension of the gel which is termed as the threshold voltage, a Taylor cone is formed and the gel elongates towards the target in a whipping motion. The threshold voltage ($V_c$) at which the fibers are formed is directly proportional to the distance between the terminals ($H$). When the distance increases, the threshold voltage required is also increased as per the relation $V_c^2 \propto H^2$ (Zheng-Ming Huang et al 2003). Above the threshold voltage, finer fibers are obtained by lowering the applied voltage.
2.2.3 Effect of Applied Voltage on the Morphology of Fibers

The effect of the external parameter ie applied voltage on the morphology of nanofibers was investigated by maintaining a constant working distance of 12 cm. ImageJ software was used to determine the average fiber diameter. The applied voltage was varied between 5 to 20 kV. When the applied voltage was between 5 to 7 kV, the solvent was only pulled out of the spinneret and high viscous sol could not be pulled out due to the low applied voltage which may be less than the threshold voltage required to form the fibers. Figure 2.1 shows the SEM image of the spilling of solvent between 5-7 kV of applied voltages.

![SEM image of the spilling of solvent between 5-7 kV applied voltages](image)

Above 13 kV of applied voltages, excessive sol and non-uniform fibers were formed as found in the SEM images as shown in Figure 2.2. This non-uniformity is due to ejection of more sol due to large applied field values.
Figure 2.2  SEM image of non-uniform fibers formed above 13 kV of applied voltage

Beyond 20 kV of the applied field, it is too large than required and forcibly the sol is pulled out and the sol is deposited on the collector as a non-uniform layer of a film and is shown in the Figure 2.3.

Figure 2.3 SEM image of the sol deposited above 20 kV of applied voltage
Between 8-13 kV of applied voltages, with increasing electrostatic field strength, the fibers obtained appeared to be smaller in diameter with narrower distribution and uniform. The increased electrostatic force could lead to an increase in the mass throughput of the material from the nozzle, while the increased Coulombic stretching force could lead to a decrease in the fiber diameter (Jeerapong Watthanaarun et al 2005). It is evident from Figure 2.4 that the diameters of the fibers obtained appeared to be smaller with increasing electrostatic field strength. Such an observation should be solely due to the increase in the Coulombic repulsion force. This range was found to be the optimum range for the deposition of the fibers with the sol. Similar results have been obtained already (Lin-Jer Chen et al 2011). From the observations, it is found that at an optimum applied voltage of 13 kV and a working distance of 12 cm, narrow nanofibers were formed with diameter of 125 nm as shown in Figure 2.5. The formed fibers were dried for 10 h at 348 K under vacuum and then calcined for 6 h at a temperature of 873 K. The electrospinning apparatus was kept in an isolated place which is electrically insulated and free of air current.

The optimum values of the electrospinning parameters maintained for the preparation of PVA / zinc acetate /copper acetate sol to obtain the uniform fibers are given in Table.2.1. The sol with the following optimized parameter values was used to form the fibers in the electrospinning process. Conductivity of the sol was measured by EQUIP-TRONICS model EQ-660A digital conductivity meter. Viscosity of the sol was measured by Digital Viscometer.
Figure 2.4 Variation of fiber diameter with applied voltage

Table 2.1 Optimum values of electrospinning parameters maintained to obtain PVA/zinc acetate/copper acetate composite and ceramic fibers

<table>
<thead>
<tr>
<th>Electrospinning parameters</th>
<th>Optimized values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied voltage</td>
<td>13 kV</td>
</tr>
<tr>
<td>Distance between electrodes</td>
<td>12 cm</td>
</tr>
<tr>
<td>Size of the needle opening</td>
<td>27 gauge</td>
</tr>
<tr>
<td>Conductivity of the sol</td>
<td>9.61 mS/cm</td>
</tr>
<tr>
<td>Temperature of the sol</td>
<td>303 K</td>
</tr>
<tr>
<td>Viscosity of the sol</td>
<td>1.12 Pa.s</td>
</tr>
<tr>
<td>Calcining temperature</td>
<td>873 K</td>
</tr>
<tr>
<td>Time of calcining</td>
<td>6 h</td>
</tr>
<tr>
<td>Average diameter of fibers after calcining</td>
<td>50 nm</td>
</tr>
</tbody>
</table>
2.3 CHARACTERIZATION STUDIES

2.3.1 Scanning Electron Microscopy (SEM)

To observe the surface topography and cross-section of the nanofibers, Scanning Electron Microscopy images were captured using a JEOL GSM-5900 Scanning Electron Microscope. The SEM image of PVA / zinc acetate / copper acetate composite fibers obtained before calcining is shown in the Figure 2.5.

![SEM image of PVA/zinc acetate/copper acetate composite nanofibers](image)

**Figure 2.5** SEM image of PVA/zinc acetate/copper acetate composite nanofibers

This micrograph shows the general topography of the synthesized fibers. The average diameter of these fibers is found to be 125 nm. The long electrospun nanofibers exhibited a cylindrical morphology with uniform thickness and were distributed in a fibrous mat. The PVA / zinc acetate / copper acetate composite fibers were calcined at 873 K in air. Due to the removal of the organic species, the diameters of the fibers were reduced. The SEM image of the calcined ZnO/CuO composite nanofibers is shown in Figure 2.6. The average diameter of the fibers were found to be 50 nm. The
reduction in fiber diameter is attributed mainly due to the removal of PVA and the CH$_3$COO$^-$ groups of zinc acetate and copper acetate at elevated temperatures.

![SEM image of ZnO/CuO composite nanofibers](image)

**Figure 2.6** SEM image of ZnO/CuO composite nanofibers

### 2.3.2 Atomic Force Microscopy (AFM)

To confirm the cylindrical morphology, AFM images of these fibers were captured by using Atomic force microscope (NanoSurf Easy Scan2, Switzerland). Figure 2.7 shows the AFM image of the zinc acetate / copper acetate/ poly(vinyl alcohol) composite nanofibers. From the AFM image, it is obvious that the fibers are cylindrical in nature with uniform diameter. They are seen as fiber meshes coated uniformly on the collector plate.
2.3.3 Powder X-ray Diffraction Analysis (XRD)

The phase composition of the prepared samples were studied from the powder X-ray diffraction (XRD) patterns of the samples observed by a Rigaku D/max-A diffractometer fitted with CuKα radiation (\( \lambda = 1.5406 \ \text{Å} \)) at a scan speed of 0.01°/s at room temperature. The intensity data was recorded by continuous scan in \( 2\theta/\theta \) mode from 10 to 70°. Figure 2.8(a) shows the powder XRD pattern of the prepared PVA/zinc acetate/copper acetate composite fiber sample. From this figure, the semi-crystalline peak of PVA found around 20° is indexed to (101) plane of PVA (Nishio and Manley 1988). Figure 2.8(b) shows the powder XRD pattern of the nanofibers calcined at 873 K. It is found that the peak corresponding to PVA disappeared in this figure. Powder XRD spectrum of the fibers after calcining at 873 K showed peaks at 31.6°(100), 34.3°(002), 36.1°(101), 47.2°(102), 56.2°(110), 62.4°(103), 65.8°(200) and 68.5°(112) corresponding to ZnO (Yong Liu et al 2006) and 32.3°(110), 35.4°(002), 38.5°(111), 48.5°(202), 53.1°(020),

Figure 2.7 AFM image of PVA/zinc acetate/copper acetate composite fibers
57.9° (202), 61.1° (113) and 67.5° (220) corresponding to CuO agreed very well with the literature (Hongyu Guan et al 2003). The asterisk (*) marked in the Figure 2.8(b) denotes the CuO phases. The peaks in Figure 2.8(b) could be indexed to the hexagonal wurtzite zinc oxide and monoclinic copper oxide phases separately which are in very good agreement with reported values in the literature (Yong Liu et al 2006, Hongyu Guan et al 2003).

![Figure 2.8](image)

**Figure 2.8**  (a) Powder XRD pattern of PVA/zinc acetate/copper acetate composite fibers, (b) Powder XRD pattern of ZnO/CuO nanocomposite fibers

### 2.3.4 FTIR analysis

Fourier Transform Infrared spectra were obtained on Perkin Elmer Spectrum One, Fourier Transform Infrared spectrometer using KBr pellet technique. Figure 2.9(a) shows the FTIR spectrum of the PVA/zinc acetate/copper acetate composite fibers. Observations from Figure 2.9(a) show a peak at 3401 cm\(^{-1}\) corresponding to the alcoholic stretching vibrations of -OH. The
bands at 1648 and 1284 cm$^{-1}$ should attribute to the C=O and C-O stretching vibrations of the carboxyl groups respectively. The band at 1416 cm$^{-1}$ is attributed to the C-H alkane scissoring and bending vibrations. The band at 1100 cm$^{-1}$ corresponds to the C-O bending. A band at 2139 cm$^{-1}$ is attributed to C=C stretching and another band at 743 cm$^{-1}$ corresponds to –CH out of plane bending. No band is found between 1500 and 1600 cm$^{-1}$ corresponding to the typical bending frequencies of -OH. This could be interpreted that the as-synthesized fibers were dry. After calcining, a new overlapped peak around 531 cm$^{-1}$ is observed in the FTIR spectrum and is assigned to $\nu_{\text{Cu-O}}$ (Hongyu Guan et al 2003) and $\nu_{\text{Zn-O}}$ (Kwon et al 2002) and all the other peaks disappeared as shown in Figure 2.9(b). These results confirm the complete removal of organic molecules from PVA / zinc acetate / copper acetate composite fibers after calcining at 873 K and the fibers obtained after calcinations at this temperature are pure ZnO / CuO inorganic species.

Figure 2.9  (a) FTIR spectrum of zinc acetate / copper acetate/ poly(vinyl alcohol), (b) FTIR spectrum of ZnO/CuO nanocomposite
2.3.5 Energy Dispersive X-Ray (EDAX) Analysis

To determine the elemental composition, Energy Dispersive X-ray Analysis was performed by using EDX, Inca, Oxford. EDAX spectrum of the calcined ZnO / CuO nanofibers is shown in Figure 2.10 confirms the presence of the compounds CuO and ZnO in equal ratio. The EDAX spectrum shows a greater peak for the Al\(_2\)O\(_3\) sheet which was used to collect the nanofibers.

![EDAX spectrum of ZnO/CuO nanocomposite](image)

Figure 2.10  EDAX spectrum of ZnO/CuO nanocomposite

2.3.6 Optical Absorption Studies

UV spectrum was obtained by using VARIAN CARY 5E spectrophotometer. The optical absorption spectrum of ZnO / CuO nanocomposite was recorded in the wavelength region of 200 to 2000 nm and is shown in the Figure. 2.11. The very low absorption property of the synthesized fiber in the entire visible region suggests its suitability for second harmonic generation (Anie Roshan et al 2001, Venkataramanan et al 1997).
The UV absorption edge of the ZnO/CuO nanocomposite is observed to be around 240 nm. The dependence of optical absorption coefficient with the photon energy helps to study the band structure and the type of transition of electrons.

Figure 2.11  UV spectrum of ZnO/CuO nanocomposite

As a direct band gap material, the nanocomposite under study has an absorption coefficient ($\alpha$) obeying the following relation for high photon energies ($h\nu$):

$$\alpha = \frac{A(h\nu - E_g)^{1/2}}{h\nu}$$  \hspace{1cm} (2.1)

where $E_g$ is optical band gap of the nanocomposite and $A$ is a constant. From the plot of $(\alpha h\nu)^2$ versus $h\nu$ shown in the Figure 2.12, band gap energy $E_g$ is
evaluated by the extrapolation of the linear part (Amit Kumar Chawla et al 2007). The band gap is found to be 3.1 eV and the comparison of band gap energy of ZnO/CuO nanocomposite material with similar type of materials is given in Table 2.2.

![Figure 2.12 Plot of variation of \((\alpha h v)^2\) vs hv](image)

**Table 2.2 Comparison of band gap energy values**

<table>
<thead>
<tr>
<th>Name of the material</th>
<th>Band gap energy in eV</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZnO/CuO nanocomposite</td>
<td>3.10 (Present work)</td>
</tr>
<tr>
<td>ZnO</td>
<td>3.37 (Manjula G. Nair et al 2011)</td>
</tr>
<tr>
<td>CuO</td>
<td>2.78 (Junwu Zhu et al 2004)</td>
</tr>
</tbody>
</table>
2.3.7 Dielectric Studies

Pellets of ZnO/CuO composite powders of thickness 0.79 mm and 12.5 mm diameter were made by applying a pressure of 4 tonne in a hand operated hydraulic press. HIOKI 3532-50 LCR HITESTER meter was used to take the dielectric measurements with respect to frequency at different temperatures. The dielectric constant ($\varepsilon_r$) of the nanocomposite sample was determined by using the relation

$$\varepsilon_r = \frac{Cd}{\varepsilon_0 A}$$

(2.2)

where C is the capacitance, d is the thickness, $\varepsilon_0$ is the permittivity of the free space ($8.854 \times 10^{-12}$ F/m) and A is the surface area of the sample.

The variation of dielectric constant ($\varepsilon_r$) was studied as a function of frequency for the nanocomposite materials at various temperatures viz., 308, 313, 323, and 333 K and is shown in Figure 2.13. The dielectric constant has high values in the low frequency regions for the nanomaterials than for the conventional materials. The very high values of dielectric constant at low frequencies may be due to the presence of different types of polarization mechanisms (Mo Chi-Mei et al 1995). Because of the presence of interfaces in the nano materials, the application of an electric field creates dipole moments and rotates them along the applied field direction which is called as rotation direction polarization. Space charge polarization and rotation direction polarization are responsible for the high value of dielectric constant for nanomaterials at low frequencies (Nisha. J. Tharayil et al 2008).
The variation of dielectric loss was also studied as a function of frequency for calcined materials at various temperatures viz. 308, 313, 323 and 333 K and is shown in the Figure 2.14. It is evident that for all temperatures the dielectric loss decreases with increase in the frequency. This suggests that the dielectric loss is strongly dependent on the frequency of the applied field. Low dielectric loss indicates the very high purity of the synthesized materials, having lesser defects with enhanced optical quality (Christo Balarew and Rumen Duhlev 1984). Decrease in the dielectric constant and dielectric loss of the nanocomposite with respect to increase in the frequency suggests that this material can be employed in the fabrication of devices operating at high frequencies.
2.3.8 A.C. Conductivity Studies

The A.C. conductivity of the nanocomposite sample can be calculated by using the relation \( \sigma_{ac} = 2\pi\varepsilon_0\varepsilon_r f \tan \delta \), where \( \varepsilon_0 \) is permittivity in free space, \( \varepsilon_r \) is relative permittivity, \( f \) is the frequency and \( \tan \delta \) is the loss factor.

The a.c. electrical conductivity of the ZnO/CuO nanocomposite as a function of frequency and temperature is shown in Figure 2.15. Irrespective of temperature, for an increase in frequency, there is a slight increase in the electrical conductivity of the nanocomposite at the low frequency region and it is almost a constant for a wide range of frequencies. At very high frequencies in the upper MHz region, there is an abrupt increase in the conductivity. Similar results have been observed in nanocomposite materials.
Whenever the frequency increases, the conductivity also increases almost linearly beyond a characteristic frequency ($\omega_0$) which is known as the cross-over frequency and it is about 0.3 MHz in this case. As seen from Figure 2.15, the conductivity in the high frequency region indicates that the extra contribution to conductivity comes from regions which contribute to capacitative reactance and provide less impedance at higher frequencies. This portion of the graph can be fitted to a power law in frequency with an exponent in the range of 0.6 to 1. This is a general feature of some of the semiconductors (Jeppe C. Dyre 1988).

![Figure 2.15 Log frequency vs AC conductivity](image)

**Figure 2.15 Log frequency vs AC conductivity**

### 2.3.9 Non-Linear Optical Studies

The second harmonic generation efficiency of the sample was tested by Kurtz–Perry powder technique. The sample was illuminated by an Nd:YAG laser with modulated radiation of wavelength 1064 nm with pulse
energy of 4.9 mJ/pulse, pulse width of 8 ns and repetition rate of 10 Hz and the same input was also given to the KDP reference sample. The laser power was kept constant throughout the experiment. The doubling of the input frequency was confirmed by illuminating the sample by using an Nd:YAG laser of wavelength 1064 nm producing an output of green wavelength of 532 nm. The output power is found to be 11.1 times than that of KDP and 7.5 times than that of urea. The comparison of the SHG efficiency of the ZnO/CuO composite with similar materials is given in Table 2.3. 1-dimensional ZnO nanorods have exhibited higher SHG efficiency (Zhou Gui et al 2006). ZnO/CuO nanofibers are 1-dimensional in nature and it is a potential nanocomposite material for the light conversion and for the development of non-linear optical devices.

Table 2.3 Comparison of SHG efficiency of ZnO/CuO with other materials

<table>
<thead>
<tr>
<th>Name of the material</th>
<th>SHG efficiency compared with KDP</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZnO/CuO nanofibers</td>
<td>11.1 times</td>
<td>Present work</td>
</tr>
<tr>
<td>ZnO nanorod arrays</td>
<td>11.3 times</td>
<td>(Zhou Gui et al 2006)</td>
</tr>
</tbody>
</table>

2.4 CONCLUSIONS

ZnO / CuO composite nanofibers were synthesized by electrospinning of the PVA/zinc acetate/copper acetate precursor and by subsequent calcination. The fibers were characterized by SEM, AFM, XRD, FTIR, EDAX and UV spectroscopy respectively. The average fiber diameter was found to be 50 nm. Dielectric constant and dielectric loss of the sample
decrease with increase in frequency. The second harmonic generation efficiency is found to be 11.1 times than that of KDP and 7.5 times than that of urea. Due to the high aspect ratio of ZnO/CuO one dimensional nanofibers, they could effectively be used in optical communication, optical information processing, optical switching and optical sensing. Electrospinning would be a promising approach for the large scale synthesis of one dimensional ZnO / CuO nanocomposites for prolific practical applications.