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List of Abbreviations and Symbols

AFM	Atomic force microscopy
BaTiO ₃	Barium Titanate
CNF	Carbon nanofibers
CNT	Carbon nanotubes
CV	Cyclic voltammetry
DFT	Density functional theory
DMF	Dimethyl formamide
DMM	Digital multimeter
DSC	Differential scanning calorimetry
DSO	Digital storage oscilloscope
EH	Energy harvesting
ES	Electrospinning
FTIR	Fourier transform infrared spectroscopy
LED	Light emitting diode
MJ	Megajoule
MPa	Megapascal
PVDF	Poly (vinylidene) difluoride
PDMS	Polydimethyl siloxane
POM	Polarized optical microscopy
PMN-PT	Lead magnesium niobate-lead titanate
PZT	Lead zirconate titanate
SEM	Scanning electron microscopy
TGA	Thermogravimetric analysis
UV-vis	Ultraviolet-visible

XRD	X-ray diffraction
ZnO	Zinc oxide
α	Alpha
β	Beta
γ	Gamma
A	Ampere
cm	centimeter
G	Gauche
nm	nanometer
S	Siemens
N	Newton
T	Trans
V	Volt
W	Watt
T_m	Melting temperature
wt. %	weight percentage
w/v	weight to volume
μm	micrometer

PREFACE

Energy harvesting is a method to harness or acquire the useful and productive energy from the unused or waste sources. The utilization of the unused energy from the ambient sources can be done using several approaches. In this thesis, piezoelectric-based process is used to harness the waste mechanical energy from the different human motion or other relevant sources whose energy goes unused or wasted. Poly(vinylidene fluoride)-based hybrids has been prepared using different electroactive fillers which is used to generate energy from different sources and some applications are also performed which can be useful for small electronic devices. The electrospinning process used for preparing the scaffolds generates piezoelectric phase due to the in-situ mechanical stretching and poling occurring simultaneously. The scaffold is further fabricated to a device which is used for the piezoelectric based energy harvesting. Incorporation of different electroactive fillers are done to understand the role of the fillers in the enhancement of the polar phase which substantially improves the applicability of the material. The primary objective of the thesis is to develop PVDF-based hybrids from different electroactive fillers which are used to develop flexible, durable, efficient and scalable nanogenerator which can harness the waste energy to productive output. The detailed procedure, experimental, characterizations and applications are discussed in the thesis.

The thesis consists of seven chapters. The first chapter highlights the brief introduction about the energy harvesting, materials and mechanism of the phenomenon with literature survey of some previous works. The second chapter discusses the materials and experimental methods used in preparing the samples with the brief discussion about the

characterization techniques used to study the prepared samples. Third chapter demonstrates the effect of induced piezoelectric effect in PVDF-based hybrids. Tomato peel and cotton is taken as reinforcer with the PVDF matrix and role of induction of polar phase in energy harvesting applications is discussed. Fourth chapter discusses the effect of nanoclay on the PVDF fibre leading to efficient energy harvesting measured through fabricated device. Fifth chapter explores the role of Ionic liquids on enhancement of the piezoelectric active phase which results in better piezoelectric properties. In this chapter piezoelectric energy harvesting and electrochemical based measurement is studied. Sixth chapter demonstrates the effect of functionalization of carbon nanofibers on the PVDF based nanofibers for effective energy harvesting. The chapter explores theoretical / computational approach with experimental work to understand the role of fillers on the energy harvesting application. Chapter seven includes the summary of the thesis with some future insight in the field of energyharvesting.

Chapter 1

Introduction and Literature Review