# FOUNDATIONS OF HIGH PERFORMANCE POLYMERS

PROPERTIES, PERFORMANCE, AND APPLICATIONS

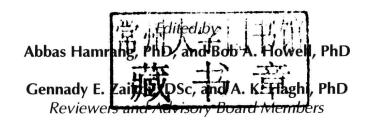
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Properties, Performance, and Applications





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## LIST OF ABBREVIATIONS

AcAc Acetiylacetone ACA Amino caproic acid **AChE** Acetylcholinesterase AFD Average fiber diameter Artificial neural network ANN ANOVA Analysis of variance **APPh** Ammonium polyphosphate Basis superpositional error BSSE

CA Contact angle
CaCO<sub>3</sub> Calcium carbonate
CB Carbon black

CCD Central composite design c-di-GMP 3', 5'-Cyclic diguanylate CDS Clinical Diagnostic Station

CF Carbon fibers CHT Chitosan

CMC Cell membrane complex CNT Carbon nanotubes

CVD Chemical vapor deposition

DACA Diacetonealcohol
DAQ Data acquisition
DD Deacetylation degree
DGC Diguanylate cyclase
DLS Dynamic light scattering
DMF Dimethylformamide

DSC Differential scanning calorimetry
DWNT Double-walled carbon nanotube

ECG Electrocardiogram
ER Epoxy resin
FS Fine suspensions

GTP Guanosine-5'-triphosphate HDPE High density polyethylene

HP High pass

ICD Implantable Cardioverter Defibrillator

LBM Lattice Boltzmann method

xvi List of Abbreviations

LMC Low-molecular compound LMCS Low molecular weight chitosan

LP Low pass

MFD Mean fiber diameter

MWNTs Multi-walled carbon nanotubes

NS Nanostructures

ODE Ordinary differential equation

PAN Polyacrylonitrile PCL Polycaprolactone

PCM Polymeric composite materials

PEO Polyethylene oxide PEPA Polyethylene polyamine

PP Polypropylene
RI Relative importance
RMSE Root mean square errors

RSM Response surface methodology

SDS Sodium dodecyl sulfate

SDS-PAGE SDS polyacrylamide gel electrophoresis

SEM Scanning electron microscope SI units System International d'unites

StdFD Standard deviation of fiber diameter SWNTs Single-walled carbon nanotubes

TiO<sub>2</sub> Titanium dioxide

UCM Upper-convected Maxwell WSN Wireless Sensor Networks ZPVE Zero-point vibration energy

### **PREFACE**

Polymers have a significant part in human existence. They have a role in every aspect of modern life, such as health care, food, information technology, transportation, energy industries, etc. The speed of developments within the polymer sector is phenomenal and at same time crucial to meet the demands of life today and in the future. Specific applications for polymers range from adhesives, coatings, painting, foams, and packaging to structural materials, composites, textiles, electronic and optical devices, biomaterials, and many other uses in industries and daily life. Polymers are the basis of natural and synthetic materials. They are macromolecules and in nature are the raw material for proteins and nucleic acids, which are essential for the human body.

Cellulose, wool, natural and synthetic rubber, and plastics are well-known examples of natural and synthetic types. Natural and synthetic polymers play a massive role in everyday life, and a life without polymers really does not exist.

Previously, it was believed that polymers could only be prepared through addition polymerization. The mechanism of the addition reaction was also unknown and hence there was no sound basis of proposing a structure for the polymers. Studies by researchers resulted in theorizing the condensation polymerization. This mechanism became well understood, and the structure of the resultant polyester could be specified with greater confidence.

In 1941/1942 the world witnessed the infancy of polyethylene terephthalate or better known as the polyester. A decade later for the first time polyester or cotton blends were introduced. In those days Terylene and Dacron (commercial names for polyester fibers) were miracle fibers but still overshadowed by nylon. Not many would have predicted that decades later, polyester would have become the world's inexpensive, general purpose fibers as well as becoming a premium fiber for special functions in engineering textiles, fashion, and many other technical end uses. From

xviii Preface

the time nylon and polyester were first used there have been an amazing technological advances that have made them so cheap to manufacture and widely available.

These developments have made the polymers such as polyesters contribute enormously in today's modern life. One of the most important applications is the furnishing sector (home, office, cars, aviation industry, etc.) which benefits hugely from the advances in technology. There are a number of requirements for a fabric to function in its chosen end use, for example, resistance to pilling and abrasion, as well as dimensional stability. Polyester is now an important part of upholstery fabrics. The shortcomings attributed to the fiber in its early days have mostly been overcome. Now it plays a significant part in improving the life-span of a fabric, as well as its dimensional stability, which is due to its heat-setting properties.

About half century has passed since synthetic leather, a composite material completely different from conventional ones, came to the market. Synthetic leather was originally developed for end-uses such as the upper of shoes. Gradually other uses such as clothing steadily increased the production of synthetic leather and suede. Synthetic leathers and suede have a continuous ultrafine porous structure comprising a three-dimensional entangled nonwoven fabric and an elastic material principally made of polyurethane. Polymeric materials consisting of the synthetic leathers are polyamide and polyethylene terephthalate for the fiber and polyurethanes with various soft segments, such as aliphatic polyesters, polyethers, and polycarbonates for the matrix.

New applications are being developed for polymers at a very fast rate all over the world at various research centers. Examples of these include electroactive polymers, nano products, robotics, etc. Electroactive polymers are special types of materials that can be used, for example, as artificial muscles and facial parts of robots or even in nano robots. These polymers change their shape when activated by electricity or even by chemicals. They are light weight but can bear a large force which is very useful when being utilized for artificial muscles. Electroactive polymers together with nanotubes can produce very strong actuators. Currently research works are carried out to combine various types of electroactive polymers with carbon nanotubes to make the optimal actuator. Carbon nanotubes are very strong, elastic, and they conduct electricity. When they are used as an