

Contents

| | |
|------------------------------|-------|
| Abstract | i |
| Declaration | vi |
| Certificates | vii |
| Acknowledgement | ix |
| Table of Contents | xi |
| List of Tables | xvi |
| List of Figures | xvii |
| List of Abbreviations | xxv |
| List of symbols | xxvii |

Chapter I: Introduction

| | |
|---|----|
| 1.1 Background | 1 |
| 1.2 Rare earth oxide (REO) based nanostructures | 3 |
| 1.3 Rare earth oxyfluoride systems | 7 |
| 1.4 Properties of RE oxides and oxyfluoride based nanoscale systems | 9 |
| 1.5 Effect of swift heavy ion irradiation on nanomaterials | 10 |
| 1.6 Principles of rheology and scope of non-Newtonian fluids | 13 |
| 1.7 Biophysical perspectives of RE oxide based nanosystems | 16 |
| 1.8 Thesis objective and structure | 17 |

Chapter II: Synthesis, characterization and growth mechanism of Gd₂O₃ nanosystems

| | | |
|-------|---|----|
| 2.1 | Synthesis principle and basic characterization | 34 |
| 2.2 | Gd ₂ O ₃ nanoparticles | 35 |
| 2.2.1 | Synthesis and characterization of undoped and Tb ³⁺ doped Gd ₂ O ₃ nanoparticles | 35 |
| 2.2.2 | Optical characteristics of undoped and Tb ³⁺ doped Gd ₂ O ₃ nanoscale systems | 37 |
| 2.3 | Gd ₂ O ₃ nanorods | 42 |
| 2.3.1 | Synthesis and characterization of Gd ₂ O ₃ nanorod powders | 42 |
| 2.3.2 | Synthesis, growth mechanism of Gd ₂ O ₃ nanorods obtained from nanoparticle seeds | 52 |
| 2.4 | Concluding remarks | 61 |
| | References | 62 |

Chapter III: Impact of energetic ion irradiation on Gd₂O₃ nanorods and interrelated optical emission and spin-spin relaxation feature

| | | |
|-------|--|----|
| 3.1 | Irradiation of Gd ₂ O ₃ nanorod systems | 70 |
| 3.1.1 | Characterization techniques employed | 71 |
| 3.1.2 | Structural and morphological evolution | 71 |
| 3.1.3 | Raman spectroscopy analysis | 74 |
| 3.1.4 | Theoretical treatment on energy deposition | 76 |
| 3.1.5 | Mechanism of formation of tamarind- shaped nanorods at a higher fluence | 77 |
| 3.2 | Interrelated optical emission and spin-spin relaxation response in Gd ₂ O ₃ nanorods | 79 |
| 3.3 | Concluding remarks | 84 |
| | References | 85 |

Chapter IV: Nanoscale gadolinium oxyfluoride (Gd₄O₃F₆) systems with Eu³⁺ inclusion

| | | |
|-----|---|----|
| 4.1 | Synthesis of Eu ³⁺ doped Gd ₄ O ₃ F ₆ nanosystems | 91 |
| 4.2 | Microstructural and morphological analyses of Gd ₄ O ₃ F ₆ nanosystems | 91 |
| 4.3 | Optical absorption and photoluminescence responses of GOF systems | 94 |

| | | |
|-----|---|-----|
| 4.4 | IR active molecular vibrational characteristics | 98 |
| 4.5 | Manifestation of Raman active modes | 99 |
| 4.6 | Concluding remarks | 101 |
| | References | 101 |

Chapter V: Magnetorheological study of Gd₂O₃ nanorod based fluids

| | | |
|-------|--|-----|
| 5.1.1 | Gamma irradiation experiment on Gd ₂ O ₃ based nanorod systems | 106 |
| 5.1.2 | Magnetorheological property of Gd ₂ O ₃ nanorod based fluids | 107 |
| 5.2 | Concluding remarks | 112 |
| | References | 113 |

Chapter VI: Biophysical relevance of nanoscale Gd₂O₃

| | | |
|-------|---|-----|
| 6.1 | Biophysical characterization: Cytotoxicity and cell viability tests | 118 |
| 6.1.1 | Isolation, culture, and treatment of lymphocytes | 118 |
| 6.1.2 | Membrane stability assay | 118 |
| 6.1.3 | Cell culture and treatment condition | 119 |
| 6.1.4 | MTT assay | 119 |
| 6.1.5 | Cell viability test | 120 |

| | | |
|--|--|------------|
| 6.1.6 | Apoptosis study by AO/EtBr | 120 |
| 6.2 | Discussion on biophysical assessment | 121 |
| 6.2.1 | Membrane stability test on peripheral blood mononuclear cell (PBMC) due to nano-Gd ₂ O ₃ loading | 121 |
| 6.2.2 | A comparative view on cancer cell viability due to Gd ₂ O ₃ nanoparticle and nanorod loading | 123 |
| 6.3 | Concluding remarks | 125 |
| | References | 126 |
| Chapter VII: Conclusions and future direction | | 130 |
| Appendix | | |
| List of Publications | | |
| Addenda | | |