

Thermo-Mechanical Investigation of Nanoreinforcements Doped Elastomeric Nanocomposite Thermal Insulations



By

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**School of Chemical and Materials Engineering (SCME)
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**This work is submitted as a PhD thesis in partial fulfillment of the
requirement for the degree of**

(PhD in Materials and Surface Engineering)

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Thesis Submission Certificate

It is to certify that work in this thesis has been carried out by Ms. Sadia Sagar (Reg# 2009-NUST –TfrPhD-MS-E-83) and completed under my supervision at the School of Chemical and Materials Engineering, National University of Sciences and Technology, H-12, Islamabad, Pakistan.



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REPORT OF DOCTORAL THESIS DEFENCE

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It is certified that PhD Thesis Titled "Thermo-mechanical Investigation of Nanoreinforcement Doped Elastomeric Nanocomposite Thermal Insulations" by Regn No 2009-NUST-TfrPhD-MS-E-83 Ms Sadia Saghar has been examined by us. We undertake the follows:

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List of Publications

➤ International Publications

1. M Bassyouni, Nadeem Iqbal, **Sadia Sagar**, Mohammad Bilal Khan, Umair Javaid, Ablation and thermo-mechanical investigation of short carbon fiber impregnated elastomeric ablatives for ultrahigh temperature applications, *Polymer Degradation and Stability*, DOI: org/10.1016/j.polymdegradstab.2014.08.032
2. **Sadia Sagar**, Nadeem Iqbal, Asghari Maqsood, Muhammad Shahid, Nazar Abbas Shah, Tahir Jamil and Mohamed Ismail Bassyouni, Fabrication and thermal characteristics of functionalized carbon nanotubes impregnated polydimethylsiloxane nanocomposites, *Journal of Composite Materials*, DOI: 10.1177/0021998314528733
3. **Sadia Sagar**, Nadeem Iqbal, Asghari Maqsood, and M. Bassyouni, MWCNTS Incorporated Natural Rubber Composites: Thermal Insulation, Phase Transition and Mechanical Properties, *IACSIT Int. J. Eng Tech*, DOI: 10.7763/IJET.2014.V6.689, Vol. 6, No. 3, June 2014.
4. **Sadia Sagar**, Nadeem Iqbal, Asghari Maqsood, Umair Javaid, Thermogravimetric, differential scanning calorimetric and experimental thermal transport study of MWCNT/NBR nanocomposites, *J Therm Anal Calorim*, DOI 10.1007/s10973-013-2949-y
5. **Sadia Sagar**, Nadeem Iqbal, Asghari Maqsood, Multiwalled carbon nanotubes impregnated rubber nanocomposites: thermal transport/decomposition and differential scanning calorimetric study, *J. Reinfor Plast Comp*, DOI: 10.1177/0731684413484184
6. **Sadia Sagar**, Nadeem Iqbal, Asghari Maqsood, Dielectric, electric and thermal properties of carboxylic functionalized multiwalled carbon nanotubes impregnated polydimethylsiloxane nanocomposite, *J Phys: Conference Series* 439 (2013) 012024, DOI:10.1088/1742-6596/439/1/012024
7. Nadeem Iqbal, **Sadia Sagar**, Mohammad Bilal Khan, Mohamed Ismail Bassyouni, Zaffar M. Khan, Aluminum Silicate Fibers Impregnated Acrylonitrile Butadiene Rubber Composites: Ablation, Thermal Transport/Stability, and Mechanical Inspection, *J. Appl. Polym. Sci.* 2013, DOI: 10.1002/APP.39717
8. Nadeem Iqbal, Mohammad Bilal Khan, **Sadia Sagar**, Asghari Maqsood, Fabrication and Characterization of Multiwalled Carbon Nanotubes/Silicone Rubber Composites, *J. Appl. Polym. Sci.* 2013, DOI: 10.1002/APP.38410
9. Nadeem Iqbal, **Sadia Sagar**, Mohammad Bilal Khan, Hafiz Muhammad Rafique, Elastomeric Ablative Nanocomposites Used in Hyperthermal Environments, *Polym Eng Sci*, DOI 10.1002/pen.23573
10. Nadeem Iqbal, **Sadia Sagar**, Mohammad Bilal Khan and Hafiz Muhammad Rafique, Ablation, thermal stability/transport and mechanical investigations of modified nanokaolinite impregnated acrylonitrile butadiene rubber composites, *Journal of Composite Materials*, DOI: 10.1177/0021998313484948
11. Nadeem Iqbal, **Sadia Sagar**, and Mohammad Bilal Khan, Comprehensive Ablation Characteristics of Ceramic Fibers Impregnated Rubber Composites, *IACSIT Int. J. Eng Tech*, Vol. 6, No. 3, June 2014, DOI: 10.7763/IJET.2014.V6.688

➤ **Submitted research articles to International Journals**

1. **Sadia Sagar**, Nadeem Iqbal, Asghari Maqsood, Experimental thermal transport evolution of nanoclay reinforced polymer composites, Experimental Heat transfer, ISSN: 0891-6152
2. **Sadia Sagar**, Nadeem Iqbal, Asghari Maqsood, A Novel Route to Synthesize Nanokaolinite and its Effects on the Thermo-Mechanical Properties of Acrylonitrile Butadiene Rubber Nanocomposites, Composite Science and Technology, ISSN:0266-3538
3. Nadeem Iqbal, **Sadia Sagar**, M.B. Khan, Zaffar M. Khan, Spectra Fibers Impregnated Polymer Composites: Ablation, Thermal Conductivity/Decomposition and Mechanical Investigation, Composite Science and Technology, ISSN: 0266-3538
4. Nadeem Iqbal, **Sadia Sagar**, Mohammad Bilal Khan, Asghari Maqsood, The role of Multiwalled Carbon Nanotubes to enhance Ablation, Mechanical and Thermal Properties of Nitrile Butadiene Rubber, Carbon, ISSN:0008-6223
5. Nadeem Iqbal, **Sadia Sagar**, Mohammad Bilal Khan, NBR/Phenolic resin blended ablative composites, Journal of Applied Polymer Science, ISSN: 1097-4628
6. Nadeem Iqbal, **Sadia Sagar**, Taimoor A. Khan, Faisal Iqbal, Saad Mehfooz, Mohammad H. K. Tareen, Nasir M. Ahmad, Effect of Quenching Temperatures on the Properties and Performance of Kevlar Supported IPP Membranes, Journal of Applied Polymer Science, ISSN: 1097-4628

➤ **International Conference Papers**

1. **Sadia Sagar**, Nadeem Iqbal, Asghari Maqsood, Thermo-mechanical and differential calorimetric study of the grapheme oxide impregnated EPDM rubber nanocomposites, NanoTech2014, Washington DC, USA. **(Winning Best Presentation Award)**
2. **Sadia Sagar**, Nadeem Iqbal, Asghari Maqsood, MWCNTS Incorporated Natural Rubber Composites: Thermal Insulation, Phase Transition and Mechanical Properties, ICCEM 2013, China. **(Winning Best Presentation Award)**
3. **Sadia Sagar**, Zaffer M Khan, Nadeem Iqbal, Asghari Maqsood, Thermomechanical study of Nanoclay-Nitrile butadiene rubber composites, IBCAST, Islamabad. (2013) **(Best Poster Presentation Award)**.
4. **Sadia Sagar**, Nadeem Iqbal, Asghari Maqsood, Dielectric, electric and Thermal properties of Carboxylic Functionalized Multiwalled Carbon Nanotubes Impregnated Polydimethylsiloxane (PDMS) composite. VASSCAA -6 (2012) **(Winning Second Prize in Poster Presentation)**.
5. **Sadia Sagar**, Nadeem Iqbal, Shakaib Arslan Gursal, Asghari Maqsood, Functionalization & uniform dispersion of MWCNTs into PDMS, Nano Africa, South Africa (2012) **(First Prize in Oral Presentation)**.
6. Nadeem Iqbal, **Sadia Sagar**, Mohammad Bilal Khan, Comprehensive Ablation Characteristics of Ceramic Fibers Impregnated Rubber Composites, ICCEM 2013, China.
7. **Sadia Sagar**, Zaffer M Khan, Nadeem Iqbal, Asghari Maqsood, A comparative study on thermal & mechanical evaluation of diverse fibers impregnated polymer composites, IBCAST, Islamabad. (2013) (Oral Presentation).

8. Nadeem Iqbal, **Sadia Sagar**, M.B. Khan, Asghari Maqsood, Zaffar M. Khan, A Comprehensive Ablation Investigation of Kevlar/NBR Ablative Composites, IBCAST, Islamabad. (2013) (Oral Presentation).

➤ **Books**

1. **Sadia Sagar**, Nadeem Iqbal, M.B. Khan, High Strength Composites: Synthesis and Mechanical Testing of Particle and Fiber Reinforced High Strength Composite Materials Published in VDM. UK

In the Name of Allah, the Most Beneficent, the
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Dedication

*I dedicate my PhD dissertation to my respected father
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