Review Report on PhD Thesis

Faculty: **Central European Institute of Technology**
Brno University of Technology in Brno

Academic year: **2018/2019**

Student: **Ing. Marek Zbončák**

Doctoral study program: **Advanced Materials and Nanosciences**

Field of study: **Advanced Materials**

Supervisor: **prof. RNDr. Josef Jančář, CSc.**

Reviewer: **prof. Alfred Crosby**

PhD thesis title: **Magnetically assembled nanoparticle structures and their effect on mechanical response of polymer nanocomposites**

Topicality of doctoral thesis: This doctoral thesis focuses on the assembly of nanoparticles within a polymer matrix and the relationship of the assembled structure to the mechanical properties of the polymer nanocomposite. Overall, this topic is very timely and highly relevant to current scientific research pursuits in the field of materials science, as well as the development of adaptable, hierarchical materials for a range of technological applications. Although several research studies related to the assembly of magnetic nanoparticles have been previously published, as the dissertation properly describes, the knowledge of the kinetics of assembly and the relationship between assembled strucutre and mechanical properties is limited. These specific aims of the written dissertation increase the impact of this work signficantly, and its publication will be a valued contribution to the scientific literature.

Meeting the goals set: The goals of the dissertation were: 1) To quantify the impact of the initial particle packing and magnetic force on the structural size scales of the assembled nanoparticle structures; 2) To quantify the kinetics of assembly as a function of particle loading and magnetic force; and 3) To relate the features of the assembled nanopaticle features to the mechanical properties of the polymer nanocomposite above and below the glass transiition temperature. The results presented within the dissertation clearly meet these goals.

Problem solving and dissertation results: The aims and approach undertaken in completing this dissertation are important and non-trivial. These studies require particular care to experimental consistency and breadth in terms of varied parameters in order to isolate governing processing-

structure-property relationships. The dissertation has succeeded in this regard. Furthermore, the dissertation provides an appropriate balance of „raw" data results, such as the tabulated micrographs of assembled nanoparticle structures and the dynamic mechanical properties as a function of magnetic force, and higher order analytical plots, such as the effect of magnetic field on the normalized relative modulus. Figure 37, on page 75, is an excellent example of these results that will have a broad and lasting impact, separating this dissertation work from many previous publications in the same field.

Importance for practice or development of the discipline: As mentioned above, the topic and results of this disseration have direct, important implications in the development of advanced materials for a range of technological applications. A current need in the discipline is the development of strategies that allow for a single composition, such as nanoparticle and polymer loading, to be processed under slightly different conditions to achieve vastly different properties. This dissertation builds upon recent developments in demonstrating that external magnetic fields applied to magnetic particles can satisfy this need, but importantly, this dissertation provides quantitative guidelines of how the tiime of proces and strength of the field impacts the structure and mechanical properties of the composite. These quantitative guidelines are important for industrial materials scientists to estimate the value proposition of building such processing controls into their current manufacturing procedures, and allow device engineers to estimate the impact of such materials on their end performance.

Formal adjustment of the thesis and language level: The organization of the thesis is clear, providing appropriate background knowledge to the reader and easily-accessed results and discussion. The writing of the dissertation is also clear.

Questions and comments: Although the disseration results and discussion stimulates many interesting questions related to future materials science reserach pursuits, I only have two questions of curiousity that I would like to share in this review. First, did the author quantify the kinetics of movement of isolated nanoparticles, i.e. at very dilute concentrations, as a function of magnetic field? Second, has the author attempted to measure the near-particle or intra-assembly mechancial properties of the polymer matrix? In asking these two questions, I do not require a formal answer, but I am simply asking them to generate thought and discussion for future research directions.

Conclusion: Overall, this dissertation describes a comprehensive study of the processing-structure-property relationships for magnetic nanoparticles dispersed in a polymer matrix. The combination of „raw" and „analytically higher order" results enhances the impact of this dissertation to researchers both within the specific discipline of polymer nanocomposites and beyond. The organization, writing, and figure composition of the dissertation further enhances the impact of the work. This is a very high quality dissertation, which clearly meets and exceeds the requirements for obtaining a PhD degree.

In my opinion, the reviewed thesis fulfill/doesn´t fulfill all requirements posed on theses aimed for obtaining PhD degree. This thesis is/isn´t ready to be defended orally, in front of respective committee.

In University of Massachusetts Amherst, USA, November 16, 2018

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prof. Alfred J. Crosby

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