Ain Shams University
Faculty of Engineering
Design and Production Engineering

Studying of factors influencing the use of cellulose-based nanoparticles for reinforcement of polymer composites in industrial applications

A thesis submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in Mechanical Engineering

(Design and Production Engineering)

By

Khaled Mustafa Hamed Elerian

Master of Science in Mechanical Engineering

(Design and Production Engineering)

Faculty of Engineering, Ain Shams University, 2015

Under the supervision of:

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Statement

This thesis is submitted in partial fulfillment for the degree of Doctor of Philosophy in Mechanical Engineering- Design and Production department, to the Faculty of Engineering, Ain Shams University. The work included in this thesis was carried out by the author, primarily at the laboratories of the Design and Production Engineering department, Faculty of Engineering, Ain Shams University. No part of this thesis has been submitted for degree or qualification at any university.

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ABSTRACT

This study focuses on the use of cellulose-based natural fibers, extracted from date palm midribs in the form of nano particles, as reinforcement to Epoxy resin. Date palm midribs were first roughly broken to lengths of ~ 10mm in macro scale and then were chemically treated by two methods (Alkali treatment which is called Treatment1 and the other alkali and acetylation treatment which is called Treatment2). Further the material was milled down to nano scale, using a self-designed and constructed planetary ball mill, resulting in particles sizes ranging between 10.86 to 21.36 nm for Alkali treated fibers, and between 30.63 to 63.93 nm for alkali and acetylation treated fibers. Nanocomposites were prepared using a casting technique by ultrasonic dispersion method, where compounds of varying compositions (0.5 up to 5 wt% nanofiber reinforcement), were treated using amino silane coupling agent, and finally specimen were poured into rubber molds of requested shape. Nanocomposites were oven-dried at 80^{o}C for 2 hours. The mechanical performance of the composites was evaluated in terms of tensile, flexural and impact properties in addition to hardness. The results show that increasing palm midrib nano fibers content has significant effect on all mechanical properties as compared to the control sample. For the first treatment; the tensile strength has increased by an amount of 40% at 3% nano date palm midribs (NDPM) content, the tensile Young's modulus has increased by an amount of 13.6% at 5% NDPM content. The bending strength has increased by an amount of 7.2% at 0.5% NDPM content, the flexural modulus has increased by an amount of 15.36% at 0.5% NDPM content. The impact strength has increased by an amount of 196% at 3% NDPM content, the Shore D hardness has increased by an amount of 8% at 1% NDPM content. Concerning the second treatment; the tensile strength has increased by an amount of 29.74% at 3% NDPM content, the tensile Young's modulus has increased by an amount of 9.5% at 5% NDPM content. The bending strength has increased by an amount of 2.83% at 0.5% NDPM content, the flexural modulus has increased by an amount of 9.93% at 1% NDPM content. The impact strength has increased by an amount of 153% at 1% NDPM content, the Shore D hardness has increased by an amount of 8.1% at 1% NDPM content.

The results show that the alkali treatment is more suitable and provides better enhancing in all mechanical properties than the alkali and acetylation treatment.

Keywords: nanoparticles, natural fibers, biocomposites

TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 General Background On Polymer/Nanofiller Composites 2

1.2 Nanoparticles Of The Polymer Composites 2

1.3 Natural Fiber Nanocomposites 3

2 STATE OF THE ART 5

2.1 Natural Fibers 6

2.2 Date palm - Phoenix Dactylifera L 10

2.2.1 Comparison between date palm fibers and other fiber types 11

2.2.1.1 Chemical constituents of date palm fiber 11

2.2.1.2 Density of date palm fibers 12

2.2.1.3 Aspect ratio (length/diameter) of date palm fibers 12

2.2.1.4 Thermal conductivity of date palm fibers 13

2.2.1.5 Availability of date palm fiber 13

2.2.1.6 Raw fiber cost of date palm fibers 14

2.2.1.7 Elongation to break of date palm fibers 14

2.2.1.8 Specific modulus of elasticity to cost ratio of Date Palm Fiber 15

2.2.2 Conclusion 16

2.3 Chemical Treatment 16

2.3.1 Natural fiber composite 16

2.3.1.1 Natural fibers 16

2.3.1.2 Matrix 17

2.3.1.3 Factors affecting composite properties 18

2.3.1.3.1 Plant fiber structure 18

2.3.1.3.2 Thermal stability of fibers 19

2.3.1.3.3 Presence of voids 19

2.3.1.3.4 Moisture absorption of fibers 20

2.3.1.4 Surface modification of natural fibers 20

2.3.1.4.1 Physical methods 21

2.3.1.4.2 Chemical methods 21

2.3.1.4.2.1 Alkaline treatment 21
2.3.1.4.2.2 Silane treatment 23
2.3.1.4.2.3 Acetylation treatment 24
2.3.1.4.2.4 Benzoylation treatment 24
2.3.1.4.2.5 Peroxide treatment 24

2.4 Chemical Treatment Litrature 25

2.5 Silane Coupling Agent 31
2.5.1 Why silane coupling agents are used 31
2.5.2 How to choose a silane coupling agent 32
2.5.3 Calculating the quantity of silane required 33

2.6 Silane Treatment Method 34
2.6.1 For inorganic material 34
2.6.2 For organic material 35
2.6.3 Holistic mixing (in Organic-Inorganic mixture) 35

3 PROBLEM DIFINITION 36

4 OBJECTIVE AND RESEARCH STRATEGY 38

5 EXPERIMENTAL WORK 40

5.1 Materials 41

5.2 Nanoparticles preparation 43

5.3 Date Palm Midrib (DPM) Nanocomposite Preparation 44

5.4 Mechanical Characterization 47
5.4.1 Tensile test 47
5.4.2 Bending Test 48
5.4.3 Charpy Impact Test 48
5.4.4 Hardness Test 49

5.5 SEM Microscopic Analysis 49

5.6 Statistical Analysis 50

6 RESULTS AND DISCUSSION 52

6.1 Tensile Properties Of DPM Nano-Particle Reinforced Epoxy Composites 53
6.1.1 Effect of Date Palm Midribs Nanoparticles on Tensile Strength and Tensile Modulus 53

6.2 Bending Properties Of DPM Nano-Particle Reinforced Epoxy Composites 54

6.2.1 Effect of Date Palm Midribs Nanoparticles on Bending Strength and Flexural Modulus 54

6.3 Impact Properties Of DPM Nano-Particle Reinforced Epoxy Composites 57

6.4 Hardness Properties Of DPM Nano-Particle Reinforced Epoxy Composites 62

6.5 Statistical Analysis 64

7 CONCLUSIONS AND FUTURE RECOMMENDATION 65

7.1 Conclusions 66

7.2 Future Recommendations and future work 67

8 REFERENCES 69

9 APPENDICES 81

Appendix I: Planetary Ball Mill Design 83

Appendix II: Report of the Tem analysis to determine the nanoparticle size, the regional center for mycology and biotechnology, Al-azhar university 85

Appendix III: Tensile Testing Standard: DIN EN ISO 527-2 86

Appendix IV: Flexural Test Standard: DIN EN ISO 178:2003 97

Appendix V: Impact Testing Standard: DIN EN ISO 179-1: 2010 112

Appendix VI: Hardness Testing Standard: DIN EN ISO 868: 2003 139

Appendix VII: ANOVA Testing Procedure 169

Appendix VIII: Critical values of the F-coefficient at 95 % confidence level 179

Appendix IX: Summary of ANOVA test results 180

LIST OF FIGURES

Figure 2.1. Classification of natural and synthetic fibers [53]. 6
Figure 2.2. Diagrammatic representation of date palm structure, showing attachment of offshoot to mother palm, among other morphological features [59]. 10
Figure 2.3. Schematic drawings of a date palm leaf [59]. 11
Figure 2.4 The content of cellulose and lignin of coir, date palm, hemp, and sisal fibers [64]. 11
Figure 2.5 The density of the date palm compared to other types of natural fibers [64] 12
Figure 2.6 Comparison between the date palm fibers and other natural fibers with respect to the aspect ratio (L/D) [64]. 12
Figure 2.7 Comparison of the thermal conductivity of date palm with other types of natural fiber [64]. 13
Figure 2.8 The annual world production of selected types of natural fibers [64]. 14
Figure 2.9 Comparison between the cost of date palm fibers and other fiber types used in industrial applications [64]. 14
Figure 2.10 Comparison between elongation to break percentage property of date palm fiber and other natural fiber types used in industrial applications [64]. 15
Figure 2.11 Comparison of the date palm fiber's specific modulus of elasticity per cost ratio with other selected types [64]. 15
Figure 2.12 Schematic view of secondary layer of fiber cell wall structure (Bledzki& Gassan, 1999) 19
Figure 2.13 The effect of alkali treatment on cellulose fiber structure (i) untreated fiber and (ii) alkali-treated cellulose fiber (Leonard & Martin, 2002) 22
Figure 2.14 Scheme of interaction of silanes with cellulosic fibers [113]. 27
Figure 2.15. Effect of moisture on fiber – matrix interface [120]. 29
Figure 2.16 The silane coupling mechanism. 31
Figure 2.17 Silane coupling agent variations - basic structure. 32
Figure 4.1 Research strategy 39
Figure 5.1 The obtained palm midrib pieces from a laboratory hammer mill 43
Figure 5.2 JEOL JEM.1010 TEM electron microscope. 44
Figure 5.3 Vacmobile vacuum chamber 45
Figure 5.4 Sonics Vibracell ultrasonic stirrer 45
Figure 5.5 Magnetic stirrer 45

Figure 5.6 Rubber molds which are used to cast the nanocomposites samples. 46
Figure 5.7 Electrical oven 46
Figure 5.8 Standard dimensions of DIN EN ISO 527-2 1BA tensile specimen 47
Figure 5.9 LRXPlus universal testing machine 47
Figure 5.10 LRXPlus universal testing machine under bending. 48
Figure 5.11 Charpy impact tester 48
Figure 5.12 Indenter for type D durometer [126] 49
Figure 5.13 A JSM-5500 scanning electron microscope. 50
Figure 5.14 A K550X sputter coater 50
Figure 6.1 Effect of NDPMP content on tensile strength. 53
Figure 6.2. Effect of NDPMP content on tensile modulus. 54
Figure 6.3. Effect of NDPM content on bending strength. 55
Figure 6.4. Effect of NDPM content on flexural modulus. 55
Figure 6.5 SEM micrographs illustrating the fracture surface of 0.5 and 1 % reinforced epoxy nanocomposites using NDPMP which alkaline treated with 5% NAOH (a) 0.5% (200X), (b) 0.5% (1500X), (c) 1% (3000X), (d) 1% (8000X). 56
Figure 6.6 SEM micrographs illustrating the fracture surface of 0.5 and 1% reinforced epoxy nanocomposites using NDPMP which treated with (5% by wt) NAOH solution and then neuterlized by acetic acid (10% by wt) (a) 0.5% (5000X), (b) 0.5% (11000X), (c) 1% (3000X), (d) 1% (7000X). 57
Figure 6.7 Effect of NDPMP content on impact strength. 58
Figure 6.8 SEM micrographs illustrating the fracture surface of 3 and 5 % reinforced epoxy nanocomposites using NDPMP which alkaline treated with 5% NAOH (a) 3% (4000X), (b) 3% (14000X), (c) 5% (10000X), (d) 5% (5000X). 59
Figure 6.9 SEM micrographs illustrating the fracture surface of 3 and 5 % reinforced epoxy nanocomposites using NDPMP which treated with (5% by wt) NAOH solution and then neuterlized by acetic acid (10% by wt) (a) 3% (3000X), (b) 3% (5000X), (c) 5% (4000X), and (d) 5% (4000X) 60
Figure 6.10 Toughening mechanisms of nanoparticles [136]. 61
Figure 6.11. An illustration of the effect of moisture on fiber – matrix interface [118]. 61
Figure 6.12. Effect of Alkali-treated NDPMP content on shore D hardness. 62
Figure 6.13. Effect of Alkali- and acetylation-treated NDPMP content on shore D hardness. 62
Figure 7.1 shows the partial denture: 67

LIST OF TABLES

Table 2.1 presents some natural fibers, specific names, fibers types, family, and nativ regions [54]. 7
Table 2.2 Annual production of some natural fibers [54]. 7
Table 2.3. Mechanical properties of some natural fibers [54]. 8
Table 2.4 Chemical compositions of some natural fibers [54]. 9
Table 2.5 The generated quantities of agro residues, year 2008 [55]. 9
Table 2.6 Structural composition and parameters of some natural fibers (Mohanty et al. 2000; Fakirov, 2007). 17
Table 2.7 Comparison between thermoplastic and thermoset matrices [80] 18
Table 2.8 Recent works on the effect of alkali treatment on polymer composites properties 22
Table 2.9 Jute chemical composition 25
Table 2.10 Silane coupling agent recommendations for various polymers – matching organoreactivity to polymer type [135] 33
Table 2.11 The surface area of filler [135] 34
Table 5.1: Chemical composition of date palm midribs 41
Table 5.2.Properties of Biresin CR82 components [125] 42
Table 5.3.Properties of mixed BIresin Epoxy resin system [125] 42
Table 6.1 Summary of ANOVA test results 64
Table 7.1 Comparison between ZrO2 and NDPM Epoxy-based nanocomposites properties 68

LIST OF NOMENCLATURE

ABBREVIATION	DESCRIPTION
DPM	Date palm midribs
CNT	Carbon nantube
SWNT	Single-wall nanotubes
MWNT	Multi-wall Nanotubes
NDPMP	Nano date palm midribs particles
T g	Glass transition temperature
ANOVA	Analysis of variance
SS	Sum of squares
MS	Mean squares
TS	Tensile specimen
BS	Bending specimen
IS	Impact specimen
ETS	Epoxy tensile specimen
EBS	Epoxy bending specimen
EIS	Epoxy impact specimen
R	Resin
H	Hardener
DPF	Date palm fiber

CHAPTER 1

INTRODUCTION

This chapter briefly introduces the background and motivation of this study. The use of natural fibers in nano scale as reinforcement for polymeric materials currently stands in the limelight of research investigations in the field of natural fiber-based composites.