TENSILE PROPERTIES OF GROUND COLEMANITE FILLED POLYAMIDE 6.6 COMPOSITE

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Abstract - In this experimental study, uniaxial tensile properties of polyamide 6.6 (PA66) composite materials filled ground colemanite (GCOLM) have been studied. In the industry, it used that mechanical or wear resistance and / or thermal properties of industrial components with chemical or physical modification new PA66 composite materials are obtained. The aim of the study is to obtain a new micro particle filled PA66 composite material with high tensile strength and high rigidity. In order to examine the effect of GCOLM filling amount, tensile properties has been applied to PA66 and GCOLM filled PA66 in 12.5, 15, 17.5 and 20 percentages in weight (wt %) materials. Experimental results have indicated that PA66/GCOLM composite material is related to micro particle amount. It is determined that Young's Modulus, yield and breaking stress are increased with GCOLM filler amount, and the yield and the breaking strain of the composite material are decreased. Moreover, in order to make predictions about damage periods, the scanning electron microscope (SEM) analysis was examined on the impact broken surfaces of PA66/GCOLM composite material..

Keywords: Polyamide 6.6, Ground colemanite, Composite, Tensile properties.

Introduction

Mechanical behavior of semi-crystalline thermoplastics and their filled types has been the subject of many researches done in recent years. So many experimental studies have been done to understand the characteristics of deformation of these materials [1]. It is a common opinion that, in composites with micro particles, particle size, adhesion between surfaces [2] and surface characteristics influence the performance of filled system substantially. Besides, it is known that particle shape, particle distribution and filler amount rate have a significant influence on system performance [3]. During the development of knowledge on this subject, in manufacture of micro particulate and event nano particulate thermoplastic composites by physical modification a variety of substances with different particle sizes and different weight rates were tried as filling substances. However, it is impossible to reach any study about the use of ground colemanite substance as additive or filling in semi-crystalline thermoplastics with physical modification and its effect on polyamide 6.6's tensile properties. The point of this study is to determine the change of rigidity and toughness values of unmodified ground colemanite (GCOLM) filled polyamide 6.6 (PA66) composite material depending on filler amount. That is why, the effect of GCOLM substance to tensile properties of PA66 material, was experimentally examined. Results were obtained depending on the amount of GCOLM filling substance of different percentages of weight (wt%). Results are shown in graphics based on values obtained from PA66 material and changes in tensile properties are shown in graphics depending on different percentages of weight (wt%), according to introduction base value PA66 by percentages. The GCOLM filler amount effect to the uniaxial tensile properties of the PA66 material, still maintains its effect is still unclear. Therefore, in this study, the GCOLM filled polyamide 6.6 (PA66) composite material, uniaxial tensile properties, depending on the amount of GCOLM filler studied. In this study, aimed to high tensile stiffness and high tensile strength with a new micro-particle-filled PA66/GCOLM composite material to obtain.

Experimental

Materials

Density of 1140 kg/m^3 PA66 material which the commercial name is Stabamid-26 AE 1 (Rhodia Operations) was used. Eti Mine Works General Management produced GCOLM commercial named mineral was used as the additive and/or filling substance. Some of the main properties of GCOLM mineral, which is obtained in Turkey-Balıkesir-Bigadiç mine site, is given in Table 1, Table 2 and Table 3.

Table 1 Chemical Specification

Component	Unit	Content
B_2O_3	%	40.00+/-0.50
CaO	%	27.00+/-1.00
SiO_2	%	6.50 Max

Table 2 Sieve Specification

Particle Size	Unit	Content
+ 600 µm	%	0.02 Max.
+ 250 µm	%	0.50 Max.
- 75 µm	%	87.00+/-5.00
- 45 µm	%	75.00+/-5.00
Moisture	%	1.00 Max.
Bulk Density	g/cm^3	0.80-1.00

Table 3 Particle Size Distribution

Particle Size	Unit	Typical Value
Average dia. d(0.5)	µm	14.008
d (0.9)	µm	49.094
Specific Surface Area	m^2/g	1.32

GCOLM substance at rates of 0, 12.5, 15, 17.5 and 20 percentage of weight (wt %) was added to granulated PA66.

Composite Preparation
In production of PA66/GCOLM composites twin screw extrusion machine (Coperion Werner and Pleiderer ZSK 25 P8.2 E WLE) with 45 screw length (L/D), 1125 mm helix length was used. The granulated composite materials, has been under continuous extrusion parameters of 170°C to 230°C zone temperatures, kept prepared at 900 rpm speed and 30 kg / h production capacity setting and were cooled at 30 ° C water bath. Each one of composite materials in granulated shape obtained was exposed to dehumidification under 50°C for 4 hours.

Multi-Purpose Test Sample Preparation
PA66 and PA66/GCOLM composite raw materials was injection molded according to ISO 3167 to Type-1A multi-purpose test samples which have dimensions as 216 mm x 10 mm x 4 mm by an injection machine (Haitian Plastics Machinery HTF 90W) with 46 mm screw diameter (D) and 20 screw length (L/D). In molding process which was achieved by considering ISO 294-1 standard, injection parameters which are fixed 235°C as nozzle temperature, 230°C/225°C/220°C as zone temperature, 1400 bar as injection pressure, 700 bar as holding pressure, 60 s as waiting time and 30°C as die cooling temperature used. Test samples was conditioned before tests according to ISO 291.

Tensile Test
Tensile tests were done considering ISO 527-1 with a tensile testing machine (INSTRON 4411 H 4240) which has a capacity of 5 kN with Clip-on static extensometer (INSTRON 2630-111) and Bluehill-2 software (ver. 2.6) on it. According to ISO 3167 (or ISO 527-2) standard 216 mm x 10 mm x 4 mm sized Type-1A multi-purpose test samples were placed in the tensile test machine, so that injection entrance is on the fixed grip of the tensile test machine.

In the study, the effect of ground colemanite mineral amount to the elasticity modulus (E), yield strength (σ_y) thereby maximum strength (σ_M), breaking stress (σ_B), yield strain (ε_y) and breaking strain (ε_B) of PA66 and PA66/GCOLM composite materials were injected with injection molding method was determined.

Tests were done under 22°C ± 1°C temperature and %50 ± 10 humidity and for each value at least 5 test specimens were used. Obtained values were statistically considered according to Chauvenet Criteria [4]. Results are shown in graphics based on values obtained from PA66 material and changes in tensile properties are shown in graphics depending on different percentages of weight, according to introduction base value and PA66 by percentages.

Scanning Electron Microscopy
Scanning electron microscopy (SEM) studies, fracture surfaces of the samples obtained as a result of the impact test covered. With the micro views obtained, distribution of the GCOLM substance in PA66 and PA66 with filling GCOLM substance were asked to identify the interaction surfaces. The surface areas have been analyzed using with a SEM machine (Jeol JSM 6335F FEG-SEM).

Results and Discussion

Here is important of expressed; raw material for the study of PA66, such as PA66/GCOLM composite raw materials , without being exposed to the effect of the parameters have been in twin-screw extrusion. In this context, the injection molding method published PA66 and PA66/GCOLM composite materials tensile properties have been identified. PA66 material and the average particle size of 14.008 μm with GCOLM substance by weight (wt) ratio of at least 12.5% to 20% filled PA66/GCOLM composite materials, uniaxial tensile test results of Figures 1 to 5 are provided.

It's shown in the figures 1, -2, -3, -4, -5, that with 12.5% GCOLM filler content, the Young's modulus about 54%, the yield stress about 13%, breaking stress 22% increasing and the yield strain 13%, breaking strain 64% decreasing as a result of the experiments. Moreover to 12.5% GCOLM filler content the higher GCOLM filler content (15, 17.5, 20%) is basically raises the Young's modulus and decrease the yield strain, the breaking strain, the yield stress and the breaking stress. But nevertheless, 20% GCOLM filled PA66/GCOLM composite material yield stress, PA66 material yield stress, is determined to be greater than about 6%. Even, breaking stress of 20% GCOLM filled PA66/GCOLM composite material, is determined to be greater than about 14% breaking stress of PA66 material.

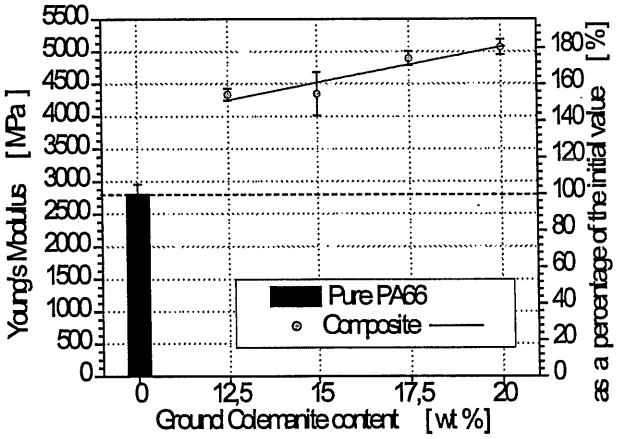

Figure 1 Young's Modulus properties of PA66 and PA66/GCOLM composite materials

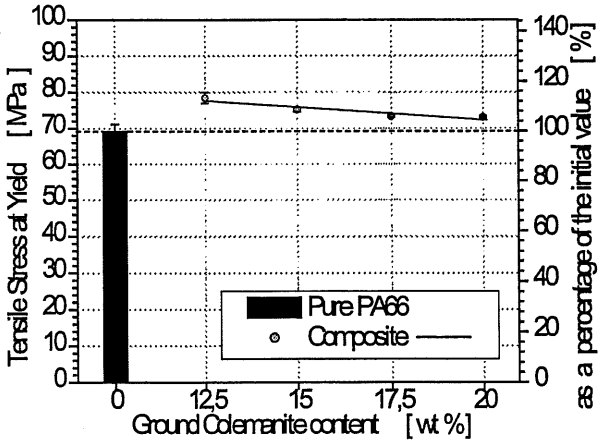

Figure 2 Yield stress properties of PA66 and PA66/GCOLM composite materials

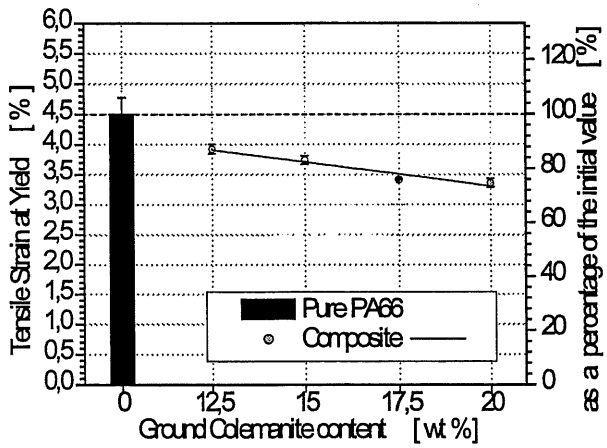

Figure 3 Yield strain properties of PA66 and PA66/GCOLM composite materials

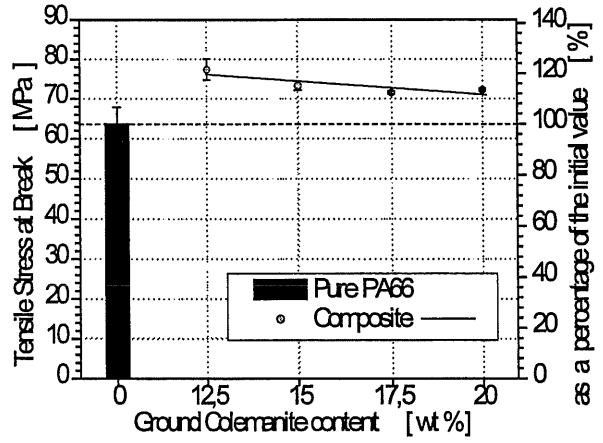

Figure 4 Breaking stress properties of of PA66 and PA66/GCOLM composite materials

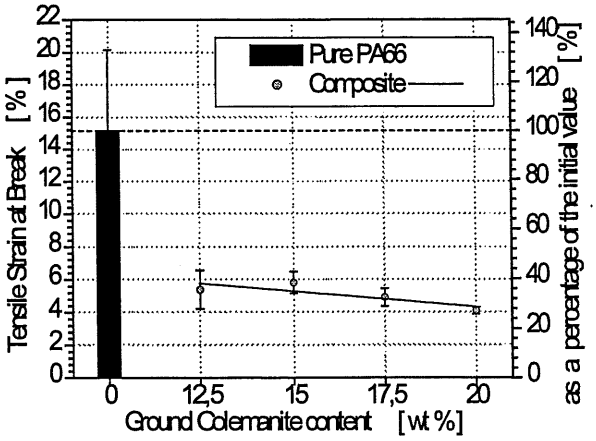

Figure 5 Breaking strain properties of PA66 and PA66/GCOLM composite materials

12.5%, 15%, 17.5% and 20% filled materials with a (x25) magnification of fracture surfaces are given in Figure 6.

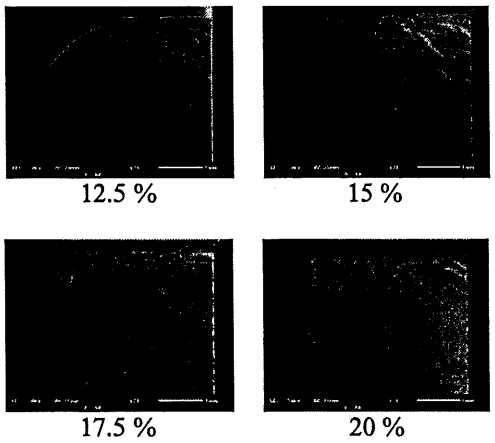

Figure 6 12.5%, 15%, 17.5% and 20% filled composite sample impact (x25)

Fracture, ductile fracture is seen as the bottom of the notch. At the end of the fracture surface, brittle fracture and so a quick fracture occurred.

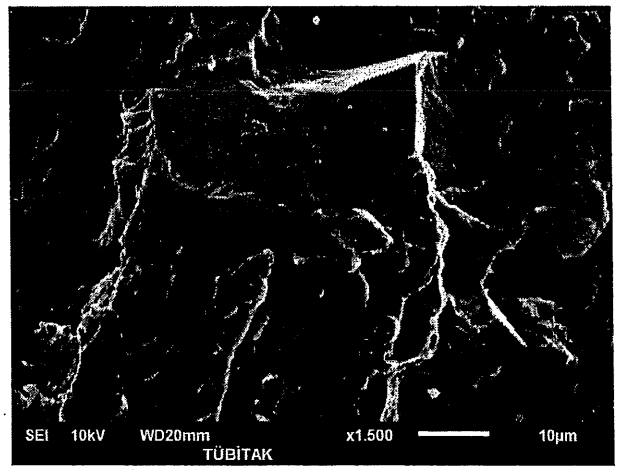

Figure 7 The SEM of 12% GCOLM filled composite surface sample impact (x1500)

SEM image in figure 7 was given as by volume 12% ground colemanite-filled polyamide composite material. The without the contribution of the interface material has been good adhesion to interface between polyamide with colemanite.

Conclusions

GCOLM substance, affected tensile properties of PA66 material with added and increasing filling amount. Each of the characteristic tensile properties of PA66 material, is affected with added and increasing GCOLM filling amount. Colemanite substance, increases the Young's modulus too the yield stress to the breaking stress and decreases the yield strain to the breaking strain of the PA66 by 12.5% filling amount. It is seen from the qualitative comparison of these affects, with the affects of other filling or reinforcement materials, depending on added filling until 12.5% by weight amount of colemanite substance, shows more similar affects, from wollastonite, talc and glass fiber substances to tensile properties of thermoplastic materials. It is known well, that the affect in this manner, in thermoplastic materials occur through conventional filling substances with smaller size of the particle average. Therefore the result in the PA66 material with a large average particle diameter of the earth colemanite substance is remarkable.

Foresight of researchers is towards the fact that the use of ground colemanite substance in smaller average particle size and/or as modified in PA66 materials as the filling substance can lead to improvement in tensile characteristic properties.

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Abstracts

General Symposia

S01 - Mixing and Compounding 1
S02 - Films and Fibers 13
S03 - Processing and Forming (Combined)* 26
S04 - Injection Molding and Molds 42
S05 - Rheology and Rheometry 61
S06 - Polymer Nanostructures and Nanocomposites 73
S07 - Natural Based and Biodegradable Polymers 107
S08 - Polymer Foams 125
S09 - Polymer Composites 137
S11 - Elastomers and Thermoplastic Elastomers 163
S12 - Modeling and Simulation 171
S13 - Polymer Blends 188
S14 - Reactive Processing 202

Special Symposia

210

S15 - Plastic Solutions for Renewable Energy Technologies
S16 - Plastic Solutions for E-mobility
S17 - Plastic Solutions for Construction and Housing
S18 - Additive Manufacturing for Plastic Components
S19 - Manufacturing of Load-Carrying Hybrid Polymer Structures
S20 - Microtribology and Surface Analysis
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S08-278 **Prediction Of An Effective Physical Foamability Of LLDPE/LDPE Blends From Rheological Assessments**
Cardoso Elisabeth Carvalho Leite, Scagliusi Sandra Regina, Lugão Ademar Benevolo*

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Schreier Peter, Altstädt Volker, Trassl Christian*

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S08-597 **Foaming Of Recycled Cross-linked Low Density Polyethylenes Via Supercritical Fluid Reactions**
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Martins Ana C., Mota Armando R., Nobrega Joao Miguel, Fonseca Carlos, Machado Ana Vera, Vaz Filipe*

S08-775 **Potential Of Carbon-Based Nanoparticles (CNT, CB, Graphene) To Increase The Nucleation Density Of Extruded Polystyrene Foams**
Okolieocha Chimezie , Altstädt Volker*

S08-821 **Foam Injection Molding Of Thermoplastic Elastomers: Blowing Agents, Foaming Process And Characterization Of Structural Foams**
Ries Stefan, Spörrer Andreas, Altstädt Volker*

S08-882 **Chemical Resistance Of Core-Shell Particles (PS/PMMA) Polymerized By Seeded Suspension**
*Ribeiro Luiz Fernando, Antunes Mariana Zimmermann, Gonçalves Odinei Hess, Machado Ricardo Antonio Francisco**

S09 - Polymer Composites

S09-1 **Single Polymer Composite Made Of Polypropylene Fabric And Matrix**
*Agrawal Bhawana**

S09-118 **Tribological Properties Of PTFE Composite Films Filled With Carbon Nanofiber**
Enomoto Kazuki, Yoshikawa Shigeki, Hirabayshi Masanori*

S09-135 **Role Of Different Compatibilizing Approaches On The Microstructure And Mechanical Properties Of Polypropylene/Talc Composites**
Homayounfar Seyedeh Zohreh, Bagheri Reza*

S09-169 **Reuse Of Rigid Polyurethane Foam As Filler For Polypropylene Matrix**
Souza Adriana M. Catelli, Melo Luiz Alberto*

S09-240 **Processing Of Microencapsulated Dyes For The Visual Inspection Of Fibre Reinforced Plastics**
*Kerschbaum Martin**

S09-297 **Structure And Properties Of Halogen-Free Flame Retardant Poly (Vinyl Alcohol)/Melamine Phosphate Composites**
*Guo Dan, Bai Shibing, Wang Qi**

S09-328 **Structure And Antibacterial Properties Of Polydimethylsiloxane And Microcrystalline Cellulose Composites**
Jankauskaitė Virginija, Lisauskaitė Aistė, Prosyčevas Igoris, Vitkauskienė Astra*

S09-336 **Tensile Properties Of Ground Colemanite Filled Polyamide 6.6 Composite**
Mızrak Semih, Şahin Şenol, Şahin Tülin*

S09-345	**Effect Of Talc On The Hoop Stress Of Polypropylene Blok Copolymer Composite Pipes** *Findik Erkut*, Şahın Şenol*
S09-352	**Tensile Properties Of Calcium Carbonate Filled Polypropylene Block Copolymer Composite Pipes** *Altay Anıl, Akten Hande, Şahin Şenol**
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S09-533	**Effect Of The Injection Processing On The Mechanical Properties Of The Nanocoposites Polyamide 6/Glass Fiber/Montmorillonite – (PA6/GF/MMT)** *Damiani Renato Adriano, Fiori Jr. Jair, Silvano Josiane da Rocha, Neto Almir Barros da Silva Santos, Araújo Pedro Henrique Hermes de, Peterson Michael, Fiori Márcio Antônio**
S09-536	**Solid State Rheology Of Polymer Films And Layers: Influence Of The Thickness On Mechanical Properties Of A PU-Adhesive Between Metallic Substrate** *Schawe Jürgen E.K.*, Possart Wulff, Krogh Ludovic*
S09-540	**Preparation Of Polyaniline/Sodium Alanate Hybrid Using A Spray-Drying Process** *Moreira Bruna Rodrigues, Passador Fabio Roberto*, Pessan Luiz Antonio*
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S09-712	**Polymeric Biocomposites Of Poly (Butylene Adipate-Co-Terephthalate) Reinforced With Munguba Natural Fibers** *Pinheiro Ivanei Ferreira**
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S09-803	**The Filler Shape Dependent Mechanical Properties Of Wood Polymer Composites With Polyethylene And Poly(Vinyl Chloride) Matrix** *Tomaszewska Jolanta*, Sterzynski Tomasz, Krolikowski Krzysztof, Zuk Tomasz*
S09-842	**Polyamide 6/Nano-Silicon Dioxide Nanocompósitos** *Ambrósio José Donato*, Queiroz Breno Dutra*

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S01 - Mixing and Compounding

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S13 - Polymer Blends

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back to symposia

S09 - Polymer Composites

- Keynotes
- Oral Presentations
- Poster

back to S09

S09 - Polymer Composites

Poster:

S09-1: *Bhawana Agrawal*
Single Polymer Composite made of polypropylene fabric and matrix

S09-5: *S. M. Hong, C. M. Koo*
Mechanical, Dielectrical and Electromechanical Properties of SEBS/CB and SEBS/SWCNT Nanocomposites

S09-36: *Yasuya Nakayama, Toshihisa Kajiwara*
Quantifying hierarchical mixture quality in polymer composite materials: structure and inhomogeneity in multiple scales

S09-44: *Mehmet Kodal, Hümeyra Şirin, Güralp Özkoç*
Effects of Screw Speed on the Properties of Plasticized PLA/POSS Composites

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Investigating the applicability of direct analysis ion mobility for the analysis of synthetic polymers

S09-118: *K. Enomoto, S. Yoshikawa, M. Hirabayashi*
Tribological properties of PTFE composite films filled with Carbon Nanofiber

S09-135: *S. Z. Homayounfar, R. Bagheri*
Role of Different Compatibilizing Approaches on the Microstructure and Mechanical Properties of Polypropylene/Talc Composites

S09-169: *Adriana Martinelli Catelli de Souza, Luiz Alberto de Melo*
Reuse of rigid Polyurethane foam as filler for Polypropylene matrix

back to S09

S09-240: *Ch. Hopmann, M. Kerschbaum, K. Küsters*
Processing of microencapsulated dyes for the visual inspection of fibre reinforced plastics

S09-297: *D. Guo, S.B. Bai, Q. Wang*
Structure and Properties of Halogen-free Flame Retardant Poly (vinyl alcohol)/Melamine Phosphate Composites

S09-328: *V. Jankauskaitė, A. Lisauskaitė, I. Procyčevas, A. Vitkauskienė*
Structure and antibacterial properties of polydimethylsiloxane and microcrystalline cellulose composites

S09-336: *S. Mızrak, Ş. Şahin, T. Şahin*
Tensile Properties of Ground Colemanite Filled Polyamide 6.6 Composite

S09-345: *E. Fındık, Ş. Şahin*
Effect of talc on the hoop stress of polypropylene block copolymer composite pipes

S09-348: *E.G. Yıldız, Ş. Şahin, T. Şahin*
Fracture Toughness of Calcium Carbonate Filled Polypropylene Block Copolymer Composite Stored at a Place which have no daylight

S09-352: *A. Altay, H. Akten, Ş. Şahin*
Tensile Properties of Calcium Carbonate Filled Polypropylene Block Copolymer Composite Pipes

S09-353: *Ç. Yılmaz, B. Yoro, Ş. Şahin*
Effect Of Cold Drawing And Thermal Aging On Mechanical And Thermal Properties of Calcium Carbonate Filled Polypropylene Block Copolymer Composite

S09-356: *Ch. Hopmann, M. Poehler, A. Boettcher, K. Fischer, R. Schoeldgen*
Investigations on the thermoplastic fiber spraying process and the variothermal consolidation of 3D preforms

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High renewable content sandwich structures based on flax-basalt hybrids and biobased epoxy polymers

S09-464: *Hiroyuki Yamamoto, Kazushi Yamada, Hiroyuki Nishimura*
Evaluation of Long-Term Performance of Glass-Fiber Reinforced Engineering Plastics for Hot Water Supply

back to S09

S09-508: *A. L. Catto, L. S. Montagna, K. Rossini, R. M. C. Santana*
Processing of post-consumer HDPE reinforced with wood flour: effect of functionalization methodology

S09-533: *R. A. Damiani, J. Fiori Jr., J. R. Silvano, A. B. S. Santos Neto, P. H. H. Araújo, M. Peterson, M. A. Fiori*
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Preparation of Polyaniline/Sodium Alanate Hybrid using a Spray-Drying Process

S09-589: *D. A. Rodrigues, A. S. M. Oliveira, R. F. Specht, R. M. C. Santana*
Development and mechanical characterization of a composite of polypropylene (PP) with grinding sludge as fiber

S09-674: *J. H. Choi, J. S. Yoo, S. Lee, S. K. Han, H. S. Kim, K. D. Lee, J. S. Shim, J. W Lee*
Optimization of Condition for Simulant of Highly-filled Energetic Materials

S09-712: *I. F. Pinheiro, L. H. I. Mei, A. R. Morales*
Polymeric biocomposites of poly (butylene adipate-co-terephthalate) reinforced with munguba natural fibers

S09-728: *G. Ozkoc, O. Gokce, M. Kasap*
Properies of biodegradable tpu/waste chicken feathers composites and their investigation of potential use as tissue engineering scaffold

S09-761: *Marcelo F.L. Oliveira, Aline L. China, Marcia G. Oliveira, Márcia C.A.M. Leite*
Preparation and characterization of composites based on polyester and starch matrix with vermiculite

S09-803: *J. Tomaszewska, T. Sterzyński, T. Żuk, K. Królikowski*
The filler shape dependent mechanical properties of wood polymer composites with polyethylene and poly(vinyl chloride) matrix

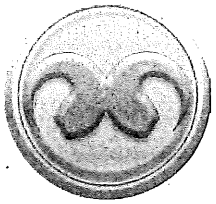
S09-842: *Ambrósio, José Donato*
Polyamide 6/Nano-Silicon Dioxide Nanocompósitos

Back to S09

S09-844: *L.S. Lima, L.B. Gonella, J. Junges, A.J. Zattera*
Influence of different nanofillers on the thermal and mechanical properties of polypropylene

S09-880: *V. de Macedo, L.C. Scienza, A.J. Zattera, C.A. Ferreira, D. Piazza*
Influence of the addition of muscovite mica and agalmatolite on the properties of polymeric nanocomposites applied to epoxy-based powder coating

S09-901: *T-M. Süld, T. Kaljuvee*
Thermal degradation behaviours of Polyethylene reinforced with inorganic filler



The Polymer Processing Society

The Polymer Processing Society (PPS) was founded in March 1985 at the University of Akron, Ohio, USA. The intent was to provide a mechanism and format for interaction and presentation of research results in the international polymer processing community. The goals of PPS are to foster scientific understanding and technical innovation in polymer processing by providing a discussion forum for the worldwide community of engineers and scientists in the field. The thematic range encompasses all formulations, conversion and shaping operations applied to polymeric systems in the transformation from their monomeric forms to commercial products.

Membership for the PPS is open to all researchers in the field, and to all persons who feel the activities of the society advance their professional development.

PPS website : www.tpps.org

Founding Meeting	Akron, OH, USA, 1985
2nd	Montreal, Canada, 1986
3rd	Stuttgart, Germany, 1987
4th	Orlando, FL, USA, 1988
5th	Kyoto, Japan, 1989
6th	Nice, France, 1990
7th	Hamilton, Canada, 1991
8th	New Delhi, India, 1992
9th	Manchester, UK, 1993
10th	Akron, OH, USA, 1994
11th	Seoul, Korea, 1995
12th	Sorrento, Italy, May 27-31, 1996
13th	New York City, NY, USA, 1997
14th	Yokohama, Japan, 1998
15th	's-Hertogenbosch, The Netherlands, 1999
16th	Shanghai, China, 2000
17th	Montreal, Canada, 2001
18th	Guimaraes, Portugal, 2002
19th	Melbourne, Australia, 2003
20th	Akron, OH, USA, 2004
21st	Leipzig, Germany, 2005
22nd	Yamagata, Japan, 2006
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24th	Salerno Italy, 2008
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27th	Marrakesh, Morocco, 2011
28th	Bangkok, Thailand, 2012
29th	Nuremberg, Germany, 2013

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Inspire AG, Switzerland

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James L. White Innovation Awardee 2013

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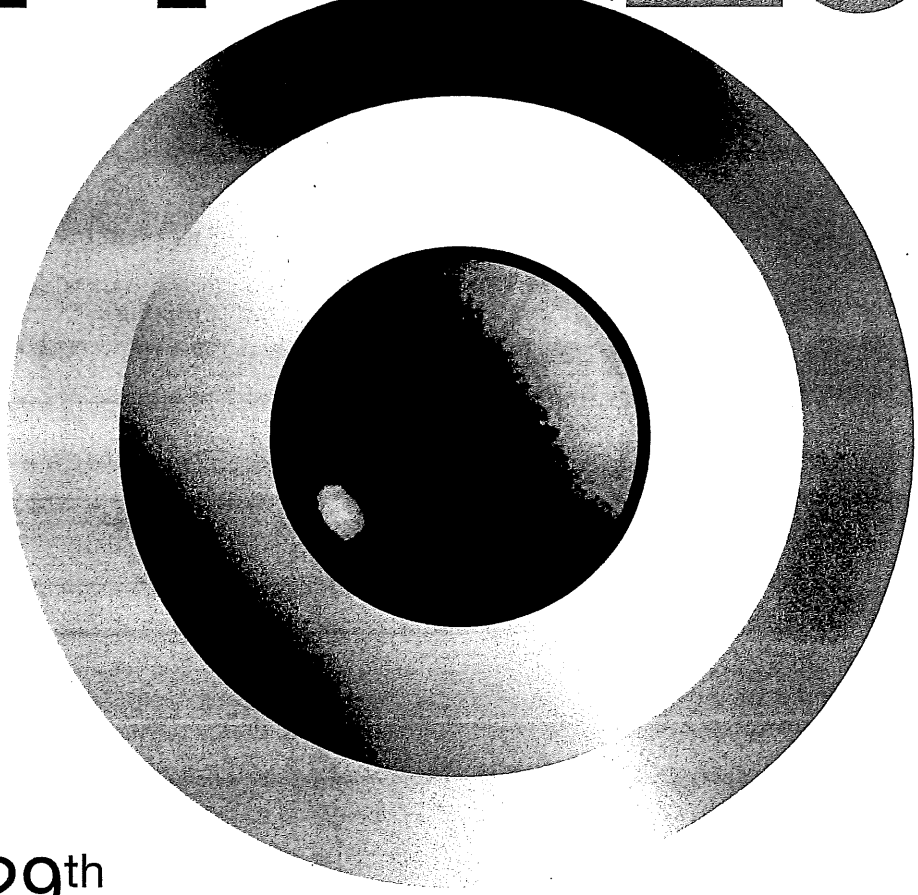
Special Symposia
Dietmar Drummer, Werner Hufenbach, Wolfgang Weinhold, Norbert Willenbacher, Volker Altstädt (Germany)

PPS 29



29th International Conference of the

POLYMER PROCESSING SOCIETY

JULY 15 – 19, 2013

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