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Newsletter

January 2016

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CALENDAR OF EVENTS

ANNUAL AWARDS GALA ..... February 19, 2016
SPRING MINITEC..... March 29, 2016
BIOPLASTIC MATERIALS TOPCON.....April 19-21, 2016
ANTEC .....May 23-25, 2016
ANNUAL GOLF OUTING .....August 2, 2016

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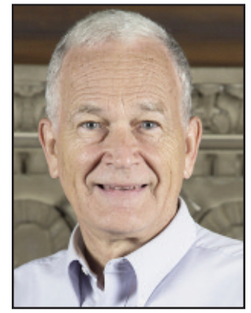
(S22) Membership
January, 2016
Section Total 307

Society of Plastics Engineers • Upper Midwest Section

January 2016 • *Volume 42*

THE SPECIALIST

UPPER MIDWEST SPE HONORS



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University of Minnesota, Twin Cities

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SEVENTH ANNUAL AWARDS GALA

Friday, February 19, 2016

The Seven Steakhouse & Sushi Restaurant - 700 Hennepin Avenue, Minneapolis

5: 15 pm – 6:15 pm Social Hour
6:15 pm – 7:45 pm Dinner and Awards Ceremony
8:00 pm – 10:00 pm Musical Performance, *GYPSY*
Cost: $90 dinner, reception and show (GYPSY)
$60/person, reception & dinner only

Please RSVP by February 15, 2016

After dinner performance of GYPSY to be held at nearby Pantages Theatre
Online reservations @ http://www.uppermidwestspe.org/upcoming-events.html
For questions please contact: Eric Swenseid, erics@harbor-plastics.com or 763-479-4772

SPRING MINITEC

Tuesday, MARCH 29, 2016 – REGISTRATION 12:30 PM • PRESENTATIONS 1:00 - 5:00 PM

Hennepin Technical College, Room J110 – Auditorium • 9000 Brooklyn Blvd, Brooklyn Park, MN 55445
More information and to register: **www.uppermidwestspe.org**

SEE DETAILS ON PAGE 2

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More information and to register: **www.uppermidwestspe.org**

METHODOLOGIES FOR SUCCESSFULLY DEVELOPING, TRAINING, AND MAINTAINING A HIGHLY SKILLED WORKFORCE.

Presentations will be given by both Routsis and Paulson. Come and hear the difference between these two companies and which best fits your business model.

Steve Murphy, Regional Manager, ROUTSIS TRAINING Steve will discuss the importance of having ongoing training in your workplace that will lead to higher margins, better employee retention. You will learn what works and advantages of various training that will shorten the time it takes train your techs. Steve will also show how management can successfully implement a system of ongoing production training.

Ted Chrzanowski, Vice President of Sales, PAULSON TRAINING PROGRAMS INC Ted will describe in detail the full Suite of training options available through Paulson Training. Attendees will have a good idea of how this suite of training resources fits together to form a comprehensive, long-term training solution for their workforce. Attendees will come away from the presentation with a very good understanding of the training options available from Paulson, advantages of each method and how they can best implement the optimum solution for their company.

ABOUT THE SPEAKERS

Ted Chrzanowski is Vice President of Sales for Paulson Training Programs having joined the company in 1994. Paulson Training Programs, Inc. is the leading provider of training to the plastic's industry. Paulson Training Solutions are a full suite of plastics training resources, both in-plant and off-site, for all of the major plastic processes. This includes online and CD/DVD interactive training in injection molding, extrusion, thermoforming and blow molding. Paulson also runs seminars throughout the country in these plastics processes. The latest addition to Paulson's training capability is our brand new 9,000 sq. ft. technical training center in Tampa where numerous injection molding seminars on a variety of topics are held. In addition, Paulson also offers customized in-plant seminars, overall plant capability assessments and machine capability studies and training. In his role as VP of Sales, Ted is responsible for coordinating, managing and implementing sales strategies for Paulson's suite of technical plastics training products. In his 22 years with Paulson, Ted has worked with over 1,000 companies, from small and medium sized operations to the largest multi-plant organizations to implement successful profit maximizing training solutions. Prior to joining Paulson, Ted worked in sales at Stanley Tools and Procter & Gamble. Ted received his undergraduate degree in Finance from the University of Connecticut, where he also earned an MBA. He is a diehard sports fan as well as a modern art enthusiast.

Steve Murphy has over 35 years' experience in the plastics industry beginning as a mold maker and holding positions such as Plant Manager, Operations Manager and Director of Operations. His hands on expertise put training and systems in place that led to profitability by reducing scrap rates and customer returns. Over the years he focused on lean manufacturing and implementing training. Eight years ago he joined Routsis Training as a Regional Manager and shares his expertise on developing employee's skills.

COST:

Advanced Registration (Thru MARCH 25 - 5:00 PM): Member: $25 • Non-Member: $50 • Students: No Charge

Late Registration: MARCH 26 - MARCH 29 / AT THE DOOR: Member: $35 • Non-Member: $60 • Students: $5

JOIN US FOR HAPPY HOUR IMMEDIATELY FOLLOWING MINITEC!; Mad Jack's • 8078 Brooklyn Blvd • Brooklyn Park, MN

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SPE Education Committee - *Tom McNamara*

Our Upper Midwest Section is proud to report that we have selected and awarded five scholarships to five very deserving students. Two of the awards were Tony Norris Scholarship Awards (2-year degree programs) in the amount of $400 and three other awards were Jerome Formo Scholarship Awards (4-year degree programs) in the amount of $500.

Tony Norris Awards went to:

Seth Amihere is a Plastics Engineering Technology student at Hennepin Technical College. Seth is active in the SPE Student Chapter and is the SPE representative on the Student Senate at HTC. He currently working as a Workshop/Laboratory Assistant at HTC in the Plastics Engineering Department. Seth has previously worked at Dalsin Industries, KEB America, and Unison Comfort Technologies. He is looking forward to an exciting career in the plastics industry.

Cody Scherber is a Plastics Engineering Technology student at Hennepin Technical College. Seth is active in the SPE Student Chapter. Cody is currently working in the Hennepin Technical College Work-study Program. He has also gained experience from employment at Advanced Extrusions. Cody hopes to use his plastics education and hands-on training to become a successful part of the plastics industry.

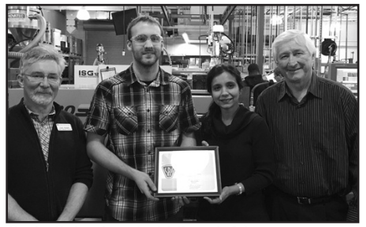
Jerome Formo Awards went to:

Gavin Borchardt is a student in the University of Wisconsin – Stout Plastics Engineering program. Gavin has been awarded the UW-Stout Chancellor's Award and is an Academic Honors Society member. He is the current President of the UW-Stout SPE Student Chapter and Lead / Organizer of the inaugural SPE Student Chapter Annual Golf Outing. His work history includes an internship at Phillips-Medisize and employment at Crystal Finishing Systems. He has volunteered for numerous activities including: Plastics Lab demo nights, lab tours, church activities, cancer fundraisers, and youth football coaching.

Michael Beeler, is also a Plastics Engineering student at the University of Wisconsin – Stout. He has been a member of the UW-Stout SPE Student Chapter since 2012. He was elected Vice President of the Student Chapter for the 2015-2016 school year. Michael has done many volunteer activities including UW-Stout move-in, campus cleanup, and State Science Olympiad. He has worked as a Research Assistant in the UW-Plastics Laboratory and as a Laboratory Assistant helping to instruct other students in the use of all of the equipment in the UW-Stout Plastics Laboratory.

Abraham Folkerts is a Composite Materials Engineering student at Winona State University. Abe is a junior at Winona State and is a transfer student from Iowa Central Community College. He played football at both schools and has demonstrated leadership both in sports as well as leading mission trips for Love Packages and Operation Christmas Child. Abe aspires to graduating with the Composites Engineering degree and one day owning his own business.

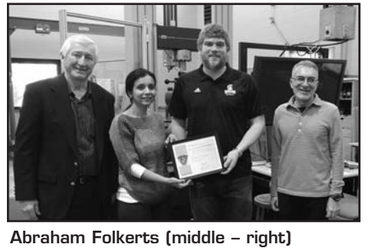
Seth Amihere (middle – left)
Hennepin Technical College



Cody Scherber (middle – left)
Hennepin Technical College

Gavin Borchardt (middle - left)
University of Wisconsin – Stout

Michael Beeler (middle – left)
University of Wisconsin Stout



Abraham Folkerts (middle – right)
Winona State University

Councilor's Corner *by Dick Bopp*

Tom McNamara - Councilor - Upper Midwest Section

Happy New Year, everyone! It is my honor and privilege to write the Councilor's Corner in this issue of *The SPEcialist* as I was proxy for our councilor, Tom McNamara, at the fall 2015 Council Meeting held in Pittsburgh on Oct. 10-11. Thank you, Tom and Shilpa for the opportunity.

Here is my summary of the meeting which I must say had a distinctly fresh style from all those previous. The event started out on Friday evening with a welcoming reception as is the usual custom. But, a new twist was the inclusion of a team building activity where all the attendees were randomly selected into teams, each given the task to build a bicycle. There were bikes for both boys and girls that were then donated to the local Y for disadvantaged children. There's nothing quite like pitting a team of individuals on an unfamiliar task to breakdown interpersonal barriers. The event also served as an effective prelude for a more action-oriented (less parliamentarian) council meeting ahead.

Financials: First the bad (maybe just, not-so-good) news. SPE had a loss in 2015 estimated at the time to be as much as $150K. Reasons given seemed understandable: We missed out on $350K exhibit sales at ANTEC due to co-locating with NPE; ANTEC Europe was cancelled; Investments in new IT infrastructure, software (If you get a chance to check out the new website, *The Chain*, I think that you will agree with me that they did a great job.). Despite this a breakeven budget is projected for 2016 with ample reason for optimism going forward.

Membership: With the new e-member initiative, SPE e-membership has grown from zero to 3000 in just 6 months. This brings the overall membership to 16,700 with a stable premium membership base of between 13,500 and 14,000.

Business Model: SPE is adapting its business model to compensate for lower income from membership dues and ANTEC revenues. (Reference: At the end of the 90's their combined income amounted to $5.5 MM, compared to $2.2 MM in 2014.) Consequently, there is a desire to shift attention more to Topcon's, advertisement sales, industry surveys and supply chain seminars. Combined, an additional $1 MM/yr is expected by 2017.

Additional & Enhanced SPE Services for Sections & Divisions:

Websites: The enhanced functionality brought about by the upgraded SPE IT infrastructure now makes it possible for sections and divisions to improve the visibility (Ad revenue) and performance of their individual websites while still maintaining full control.

Tutorial Videos: SPE has identified a partner to produce 15-20 minute problem solving video tutorials. An interesting and professionally appealing example was presented. Sections and Divisions can participate, but will need to supply content and cooperate in the on-site production. Estimated costs are about $2500/video.

Personalized and Customized Industry Newsletter: "PLASTICS Insight" is now rolled out. I hope all of you have had a chance to look it over.

Topcon Services: New software has been purchased by SPE to support TOPCONS. It has registration capability, exhibitor /sponsor management, program apps, website and marketing modules—all offered in the Topcon policy at no additional cost.

Future SPE Governance: A special Governance Task Force presented a nascent model of governance for the Society. For more details check-out president-elect, Scott Owen's posts on *The Chain*. Basically, the new model calls for a MUCH smaller, but accountable group of about 10 people—all elected by Council--who would have governing responsibility and authority. A straw poll by Council favored continuing work in refining our business model.

ANTEC and SIG's: Breakout brain-storming sessions were held on the future of ANTEC and SIG's. I attended the former led by past-president, Dick Cameron. There is growing sentiment (that I do not share) that somehow ANTEC would be more successful if it was less comprehensive, overlapping and more focused. If I may editorialize: It is precisely the diversity of SPE in its membership ranging from the operator on the floor to the R&D engineer to the college professor that maximizes our learning, communication and networking. There have been countless times when I learned about new technologies at ANTEC's that I would have otherwise missed if ANTEC was a more narrowly focused conference: Gas-assist injection molding, nanocomposites and 3D printing to name but a few. If we want more focused conferences, let's have more Topcon's. ANTEC is wonderfully unique. Viva la difference!

Lifetime Educational Giving of Chapters: Recent analysis has shown that our Sections & Divisions have literally spent millions of dollars on education. SPE intends to highlight these efforts more prominently. *We can be very proud of the wonderful work done in this regard by our own Education Committee over the years and currently chaired by Tom McNamara.*

Section & Division Committee Reports: Several Sections and Divisions were placed in provisional status. However, 'Middle East' and 'ASEAN' were approved and now are official SPE chapters signifying the increasing global nature of the Society.

As you can see, our Society is in a period of historic change. It's important that we continue to support our Councilor, the Board of Directors and SPE leadership in this great effort. If you have any concerns, suggestions or questions, please be sure to let us know. Thanks, again.

Submitted by RC Bopp, January 14, 2016

WELCOME TO OUR NEW MEMBERS - Hamid Quraishi, Membership Chair

We are pleased to welcome our newest members of the Upper Midwest Section. As of January 17, 2016, our section has 307 active members! Tell your friends and co-workers about the SPE Upper Midwest Section to help us grow and check out our website, www.uppermidwestspe.org, and the national website, www.4spe.org, to know all that SPE and this section has to offer

New Member	Affiliation
Jeffrey Schirer	Proto Labs Inc.
Gabriel Tritz	Winona State University
Eric Hall	Renewable Solutions LLC
Aevyrie Roessler	UW Madison

President's Remarks *Shilpa Manjure*

Hello to all our members again and Best Wishes for a Very Happy & Successful New Year…!

Some great thinker once said that "The only thing that is Constant is Change". We do live in times where the environment (or surrounding) is rapidly changing and for us to keep up it is even more essential to adapt ourselves at the same pace. If you have been reading about news from SPE national, you will know they are striving hard to understand what new business model will work for an international organization such as SPE while the industry (including the plastic) around it has already changed to a "sharing economy".

At the Upper Midwest we have changed the way we communicate and reach out to you. While the SPEcialist is still a prime mode of communication, we update and announce our events through email-blasts, our Website and also LinkedIn..

The main objective of this society is to promote the scientific and engineering knowledge relating to plastics. This is the first time we will be hosting a **two day conference along with SPE's Bioplastics SIG (Special Interest Group) here in Bloomington on April 20-21, 2016**. While it will be a lot of long hours at organization and planning, it will be valuable to have access to some discussions and networking with national speakers and industry peers. The conference starts with a one day tutorial on Bioplastic Standards and Material Fundamentals. I would recommend you do take advantage of this opportunity in our backyard this year!

We ended last year with an impressive seminar by industry expert, MICHAEL SEPE, reviewing fundamentals of polymer materials and as they relate to the molding process. Michael has worked in the plastics industry since 1975 and is famous as the 'Materials Analyst' based on the column he publishes for Injection Molding Magazine. The audience who attended the seminar commended the speaker on his strong background and knowledge of plastic materials.

The highlight of 2015 was certainly handing out Student Scholarship Awards to about 9 students total. We are glad to have recognized some deserving individuals. Congratulations to all of them! Please do check out more details further in this newsletter on the winners. We will be offering scholarships again this year in Fall and Spring, so do watch out for announcements on our website or via email.

Our first event for 2016 is our Annual Meeting and Awards Gala. Note this is one event that is open to your better-halves as well. This year we will be hosting it at The Seven Steakhouse and Sushi Bar on February 19, 2016. I would like to cordially invite you to an evening of fun, networking and an opportunity to meet our guest of honor, Prof. Chris Macosko, who will be inducted into the Upper Midwest Hall of Fame.

Sean Mertes, our Program Chair, has been diligently putting together a series of seminars for 2016. We will be kicking off the year with a MiniTec presented by two speakers on March 29 at our usual location – Hennepin Tech College in Brooklyn Park. As you might be aware both these companies provide training courses on injection molding fundamentals. Please plan on attending as the cost for SPE members is minimal.

Looking forward to meeting you at several events this year. Have a wonderful 2016!!

Best Regards, Shilpa Manjure

SCIENCE CORNER *continued from page 8*

Table 2: Comparison of % crystallinity as measured using DSC for compounded PLA

Grade	Crystallization Peak area (J/g)	PLA X%*	Complete crystallization time (min)**
PLA HH	21.27	28.4	3.4
PLA HL	44.86	59.8	1.7
PLA LL	38.84	51.8	1.5

*As calculated on second heating curve
** Calculated from isothermal heating for 10 min at 100°C

Table 3: Comparison of heat deflection temperature (HDT) as measured using DMA per ASTM D648 for compounded PLA-talc blends

Grade	Control PLA-talc HDT (°C) (no annealing)	Annealed PLA-talc HDT (°C)
PLA HH	54	107
PLA HL	54	130
PLA LL	54	138

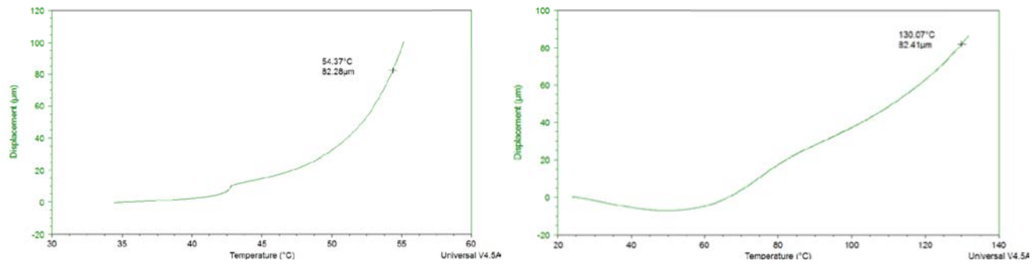


Figure 2: DMA plot for PLA HL-talc blend before and after annealing showing HDT at a displacement of 82 µm

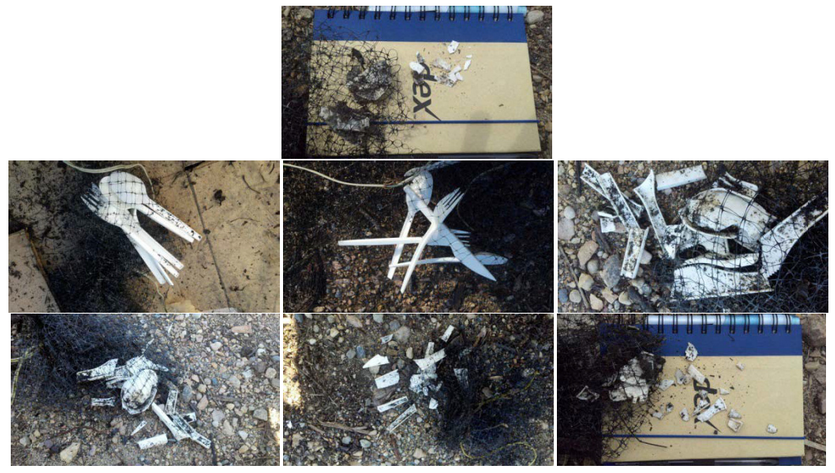


Figure 3: Disintegration of crystallized PLA HH cutlery as tested at Specialized Environmental Technologies Inc. Composting facility, MN from Day 1 through Day 18

This paper was originally published in The Proceedings of ANTEC, © 2013, and has been reformatted to fit the allotted space. Used by permission.

Conclusions

Grades of PLA with varying degree of meso-content were successfully crystallized with talc as nucleating agent to improve the thermal properties of PLA using annealing. Additionally, cutlery injection molded with compounded PLA and crystallized in a second step was shown to successfully disintegrate within standard timelines in an industrial composting facility. Compostability of cutlery with much higher % crystallinity as seen for PLA grades HL and PLA LL will be tested as continuation of this work.

Acknowledgments

We would like to thank Carver County, MN and Specialized Environmental Technologies Inc., MN for organizing compostability testing of the PLA cutlery samples. Thanks are also due to NSF for funding this project under Grant # 1127552.

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Key Words: Poly(lactic) Acid, PLA, crystallization, compostable, biodegradable, injection molding

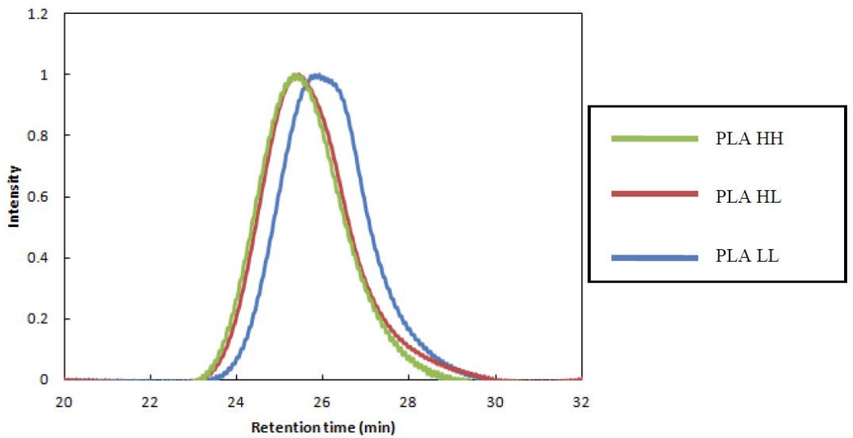

Figure 1: Molecular Weight Comparison of PLA grades using GPC

Table 1: Filler content in compounded PLA measured using Thermo Gravimetric Analysis (TGA)

Grade	Theoretical Talc Content	Talc content measured by TGA
PLA HH	20%	20.34%
PLA HL	20%	20.51%
PLA LL	20%	19.86%

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SCIENCE CORNER

IMPACT OF CRYSTALLIZATION ON PERFORMANCE PROPERTIES AND BIODEGRADABILITY OF POLY(LACTIC ACID)

Shawn Shi & Ramani Narayan, Michigan State University, East Lansing MI
Shilpa Manjure, Natur-Tec® - a division of Northern Technologies Intl. Corp., Circle Pines, MN

Abstract

Polylactic Acid (PLA) is the most widely available, renewable and compostable polymer with several unique features. However, PLA is poor in its ability to withstand elevated use temperatures above 55 ºC. As such it is common practice to either compound PLA with additives [1-2] that improve its heat deflection temperature or increase its crystallinity [3] in mold or in an extra annealing step for use in injection molded applications. The objective of this research was to study the crystallization of three PLA grades and its effect on thermal properties including compostability. Crystallization was studied using DSC and Talc was used as a nucleating agent. Crystallinity was found to vary from 25% to 60% for the various grades. The PLA was converted into test bars and cutlery and its heat distortion temperature was tested before and after annealing. Additionally, the crystallized cutlery was sent to a local composting facility and was found to disintegrate within 4 weeks, which is much sooner than the requirements of the ASTM D6400 standard of 12 weeks.

Introduction

Polylactic acid or Polylactide (PLA) is a thermoplastic aliphatic polyester derived from renewable resources, such as corn starch (in the United States), tapioca roots, chips or starch (mostly in Asia), or sugarcane (in the rest of the world). With a current global annual capacity of approximately 150,000 tonnes and projected to increase upwards of 200,000 tonnes by 2015, PLA is the most widely available biopolymer today despite its shortcomings in processability, impact resistance and thermal resistance.

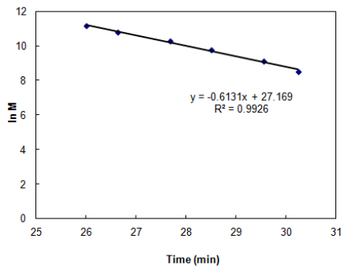
Some of the ways in which manufacturers and researchers have resolved the drawbacks of PLA are addition of additives/modifiers, chemical modification for increase in molecular weight, synthesis of pure lactide - PDLA or PLLA or morphological changes using crystallization. Addition of modifiers or additives has been helpful to improve the thermal and impact properties; however, such additions may violate compostability standards, such as ASTM D6400, especially if such components are added at levels higher than 1%. Crystallization of PLA has been studied in various ways either to improve dimensional stability [3], mechanical performance [4] or thermal performance.

The objective of this study was to not only study the effect of crystallization on properties of various PLA grades but also test compliance with international standards for compostable plastics. Kolstad [5] has investigated the crystallization behavior of copolymers L-lactide and meso- lactide and found that with 3% meso-lactide in PLA, crystallization is more than two times slower than PLLA under the same conditions. As such, various PLA grades were sourced for this study having varying D-isomer content or meso-copolymer content.

Materials and Experiments

Three injection molding grades of Poly(lactic) Acid were obtained from NatureWorks LLC. These three grades were characterized as having (1) high molecular weight, high meso-lactide content (PLA-HH), (2) high molecular weight, low meso-lactide content (PLA-HL) and (3) low molecular weight, low meso-lactide content (PLA-LL). PLA HL and LL contained very low meso-lactide, far less than 1% as compared to ~4% for the PLA-HH grade. The molecular weight was determined by gel permeation chromatography (GPC) equipped with a refractive index detector (Shimadzu, Tokyo, Japan, RID-10A) and a combination of three columns (Waters Co., Israel, Styragel HR1 THF and Styragel HR4E THF). Tetrahydrofuran was used as the mobile phase with a flow rate of 0.50 mL/min at 40 °C. A calibration with PS standards was first run to obtain

PS (M)	70000	50000	30000	17500	9000	5000
Retention Time	26	26.616 67	27.675	28.491 67	29.541 67	30.233 33
Ln (M)	11.16	10.82	10.31	9.77	9.11	8.52



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Grade	PLA HL	PLA HH	PLA LL
Mw	97000	99000	77000
Mn	70300	72400	57800

specific retention times. The Talc grade ABT2500 was supplied by Specialty Minerals. PLA was obtained in pellet form, and talc as powder with an average particle size of 2.3 micron. Both materials were used as received. Each material was dried overnight at 75 ºC and maintained in a dry environment prior to compounding.All components were dry-mixed together and then fed into a 30 mm ZSK 30 twin-screw extruder from Werner Pfleiderer with a L/D of 30. All compounds were prepared by melt extrusion with 20% talc at 180-200 ºC on a vacuum vented extruder run at 125 rpm. Prior to molding, the compounded pellets were dried for at least 12 hrs at 75 ºC and injection molded to test bars and cutlery on a 75 ton Milacron, Cincinnati equipment. Molding was conducted at room temperature and parts obtained were annealed at 100-110 °C for 5 minutes.

Performance Testing:
Molded cutlery and test bars were analyzed for % crystallinity using a Q-20 TA analysis DSC. Samples tested were heated to 200°C at 10°C/min and crystallization observed on second heating was compared for all the PLA grades. A Q-50 TA Thermogravimetric Analyzer (TGA) was used to evaluate the consistency of filler distribution. Heat distortion temperature or deflection temperature under load (HDT) was determined using DMA Q 800 as per ASTM D648. The HDT reflects the highest temperature in which a polymer could be used as a rigid material. A heating rate of 2°C/min was used. The testing was based on three-point bending with maximum stress of 0.455MPa. Sample dimensions used were 50 mm length, 12.7 mm width and 3.2 mm thickness.

Compostability Testing:
Compounded and crystallized PLA cutlery made with PLA HH was placed in two different composting piles, both consisting of mixed organics and yard waste. One pile was static and the other aerated. Stakes were used to mark where the cutlery was placed and the cutlery was dug up on a daily basis and photographed to visually record the degradation throughout the composting process. Temperatures were recorded from multiple points for each pile, and weather conditions were recorded on a daily basis.

Results and Discussion

The goal of this study was to evaluate both thermal performance and compostability of compounded PLA as a function of increased crystallinity. All three PLA grades, with varying meso content, were compounded with 20% talc. Table 1 shows evaluation of these compounds using a TGA. The compounds showed consistent filler loading into PLA with the compounding set up as described earlier. Table 2 shows the % crystallinity (X) obtained using DSC for the various PLA-talc compounds on the second heating cycle. As expected, PLA HH showed a relatively lower % crystallinity of 28.4% compared to the other two grades with lower meso content. [5] The heat of melting as obtained from DSC was adjusted for the filler content to represent J/gm of PLA instead of J/gm of compounded sample. Each PLA sample in the DSC was cooled at 50°C/min to 100°C (from 200°C) after the second heating and held for 10 min to represent annealing in-mold conditions. The actual cooling rates in the mold are much faster and as such, the times are not an exact comparison with molding cycle times but represent a fair comparison for the various grades. Table 2 shows complete crystallization time obtained for each grade. PLA HL and PLA LL not only showed higher % crystallinity but also faster crystallization rates which is an important factor for reducing cycle times in an injection molding process. To evaluate effect of crystallinity on heat resistance of the PLA grades, the PLA-talc compounds were injection molded into 3 mm test bars and annealed in an oven at 100-110 deg C for 5-10 minutes. Table 3 summarizes HDT of these bars as measured by DMA before and after annealing. The PLA test bar before annealing exhibited a very dramatic loss of modulus when heated above its glass transition temperature as shown in Figure 2a. According to the ASTM standard, the heat distortion temperature is the temperature at which the displacement is 82.5 µm on the DMA plot. Higher crystallinity compounds with PLA HL and PLA LL showed higher HDT compared to the 28% crystalline PLA HH. Overall, all crystallized PLA samples showed a significant improvement in heat resistance compared to unannealed samples which had a HDT of only 54°C. Crystalline polymeric structures in the morphology restrict the motion of other polymer molecules in the amorphous regions, thus helping to increase the overall heat distortion temperature.

It has been hypothesized that crystallinity slows down the disintegration of PLA and could in some cases prevent articles made of such crystalline PLA from meeting international standards for compostable plastics. This study evaluated cutlery, a very common foodservice item in the market today, that could be easily segregated in organic waste diversion programs along with other food waste. Spoons were made with compounded PLA HH- talc blends and annealed at 90-100 °C for 5 minutes in a convection oven. The crystallinity of these spoons, as seen in Table 2, was verified to be at 28-30%. Figure 3 shows results obtained at a local composting facility - Specialized Environmental Technologies Inc. - over a period of 18 days. As shown in the figure, the spoons easily fell apart into smaller pieces within 18 days and were completely blended with the surrounding compost (not shown in Figure) within 4 weeks. The temperature of the test piles was between 60-70°C and 52-62°C and similar results were obtained for both the static and aerated pile. The field test was able to demonstrate that crystallization of PLA up to 28%, did not affect the compostability of the material.