TPM&F

Thermoplastic Materials and Foams Division

HTTP://SPETPMF.COM/

TPM&F SCOPE

The Thermoplastic Materials and Foams Division is organized to provide a focal point for the interchange of information relating to non-vinyl thermoplastic resins including fluoropolymers, polyamides, polyesters, polyolefins, polystyrenes, polyurethanes, their filled and/or reinforced products, and their foamable and foamed products. Its interests lie in stimulating the development of scientific and engineering knowledge. By encouraging participation between producers and consumers, it aims to provide information on new developments which shall encompass synthesis, characterization, fabrication, safe handling, application, serviceability, and marketing.

Communications Excellence Award

Pinnacle Award

The Society of Plastics Engineers
6 Berkshire Blvd, Suite 306
Bethel, CT 06801
United States

CHAIRMAN'S MESSAGE — AUGUST 2018

Dear fellow SPE TPM&F Division members,

We had a great ANTEC® / NPE in Orlando: countless NPE exhibitors, high quality ANTEC® presentations, well-attended TPM&F Business Meeting, along with our TPM&F being recognized Gold Pinnacle Award and Communications Excellence Award. Our foams sessions in ANTEC® were once again well received!

Our board director Donna Davis was a shining star as she was inducted to Plastic Hall of Fame in the NPE / ANTEC®. For decades Donna has been actively contributing to SPE and the plastics industry, such as ANTEC® , TPM&F, the SPE Polyolefins Conference, and the SPE FlexPackCon. Congratulations to Donna for this well-deserved prestigious award!

Congratulations to our TPM&F ANTEC® Best Paper award winners Pardis, Ahmed Aldyasti, and Siu N. Leung from York University. The title of the best paper is "Protected biofilm growth in macroporous polyvinylidene fluoride carriers for biological organic removal from municipal wastewater".

I want to highlight the great work of our Education Committee led by Dr. Kim Mcloughlin. Students can now apply for multiple TPM&F awards including Chatterjee Travel Awards, Salvatore J. Monte Scholarship, and Michael Reedy TPM&F Scholarship. TPM&F sponsored the Plastics and Polymer Engineering Technology department at Pennsylvania College of Technology for a student tour of five plastics material suppliers in the Pittsburgh area. The two-day tour took place on April 26-27, 2018 and included 8 students and 2 faculty members. Another TPM&F sponsored event is the PlastiVan in Pittsburgh in October 2017. TPM&F grant also enabled a Student Paper Contest in U of Toronto.

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CHAIRMAN'S MESSAGE - CONTINUED

Our SPE FOAMS® Conference, Tutorial, and Exhibition is coming up in September 11-14, 2018 at the Hyatt Regency in Montreal, QC, Canada. The tutorial features the world renown foam experts Prof. Chu. Park, Prof. Hani Naguib, and Dr. Stephane Costeux. The prestigious keynote speakers are Dr Jim Throne the 2018 TPM&F Outstanding Achievement Awardee, Prof. Vipin Kumar from U of Washington, and Mr. Mario Grenier from Dyne-a-Pak. Please refer to the newsletter for the detailed technical program. I cordially invite you to participate in our SPE FOAMS® 2018.

Dr. Xiaoxi Wang
SPE TPM&F Division Chair

TPM&F BOARD MEMBER DONNA DAVIS INDUCTED TO THE PLASTICS HALL OF FAME

Leaders from the plastics machinery, materials, recycling, packaging and trade association will join the Plastics Hall of Fame at an awards dinner at NPE2018.

The Plastics Academy announced the 10 new members Jan. 4, and will induct them May 6 at NPE in Orlando, Fla.

"These new inductees proudly represent the length and breadth of our great industry with a wealth of accomplishments in polymer science, engineering, manufacturing, equipment design and business management," said Plastics Academy President Jay Gardiner. "Each individual has been elected by the living members after a lengthy screening process, which this year began with a record number of nominations."

Donna Davis
A chemical engineer, Donna Davis has worked at ExxonMobil Chemical Co. in process design and the development of polyolefin materials, from early gas-phase technology through metallocene catalyzed polymers. She was president of the Society of Plastics Engineers from 2003-2004, where she was involved in strategic activities that impacted the industry.

Davis also was the driving force behind the creation of the Polyolefins Conference. Davis will become the third woman in the Plastics Hall of Fame, joining Maureen Steinwall, president and CEO of custom injection molder Steinwall Inc., and Stephanie Kwolek, the inventor of Kevlar.

http://www.plasticsnews.com/article/20180104/NEWS/180109957/new-members-of-the-plastics-hall-of-fame-named

ANTEC®2018: BEST PAPER AWARD

We are happy to announce the ANTEC® 2018 TPM&F best paper award goes to Pardis Ghahramani, Ahmed Aldyasti and Siu N. Leung for their work on the development of PVDF foams for waste water treatment.

The following abstract is a sneak peek. The full paper will be published in TPM&F's year-end special newsletter.

PROTECTED BIOFILM GROWTH IN MACROPOROUS POLYVINYLIDENE FLUORIDE CARRIERS FOR BIOLOGICAL ORGANIC REMOVAL FROM MUNICIPAL WASTEWATER

Pardis Ghahramani1 – Presenter, Ahmed Aldyasti[2], and Siu N. Leung[1]

[1]Department of Mechanical Engineering, York University, Toronto, ON, Canada
[2]Department of Civil Engineering, York University, Toronto, ON, Canada

Abstract
Attached growth bioreactor process provides surface area to support the growth and attachment of bacteria, and thereby a means to biologically remove organics from wastewater. In this work, open-cellular polyvinylidene fluoride (PVDF) foams consisted of macroporous structures were designed and fabricated to promote the efficiency of existing biofilm carriers for wastewater treatment. A manufacturing approach that integrated compression molding and particulate leaching was employed to fabricate the PVDF foams. Different contents of salt were used as leaching agent to fabricate PVDF foams with macroporous structures of different total protected surface areas. Experimental studies were conducted to elucidate the structure-to-performance relationships of these macroporous PVDF carriers in terms of bacteria-to-carrier interaction and organic removal efficiency. in aerospace, robotics, and flexible electronics.

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HSM: Honored Service Member FE: Fellow of the Society HLM: Honorary Lifetime Member

SPE TPM&F & SPE U OF T CHAPTER STUDENT PAPER COMPETITION

We are very pleased to announce the winners of the University of Toronto's Student Paper Competition. Hosted by SPE University of Toronto Chapter in collaboration with SPE Thermoplastic Materials & Foams Division.

First Place:
MICROPLASTICS CAUSING A MACRO PROBLEM
Julia L. S. Bincik and Sabrina F. Cupryk, University of Toronto, Toronto, ON

Second Place:
THE PUSH TOWARDS SUSTAINABILITY: THE IMPACT OF PLASTICS IN FOOD PACKAGING
Linda Low

The judges were very impressed with the quality of the works submitted, and the scores were very close. The judges commented that they selected the Bincik/ Cupryk paper because it was well-researched and thoughtfully written, and they selected the Low paper because it "offered real solutions coming down the road."

On behalf of the TPM&F Division, we would like to thank and congratulate all of the authors who submitted papers. All were interesting and compelling, and they clearly resulted from solid research. The authors brought a variety of perspectives about Plastics and Sustainability, and they pointed to a broad range of solutions, from bio-based materials to legislation to individual behaviors. Their works provided thoughtful insights about the impact that the plastics industry has and can have on the future of our planet.

We wish all of the authors the very best, and we look forward to their continued contributions to sustainability efforts and to the plastics industry.

See full papers on pages 11-15.

Co-sponsored by the Society of Plastics Engineers' Thermoplastic Materials & Foams Division and Local Québec Section

FOAMS Tutorial

The tutorial on September 11-12, 2018 offers basic technical background on foaming technologies and underlying mechanisms and an overview of new trends in polymer foams. The tutorial is a must for new entrants to polymeric foaming, and for individuals seeking a strong technical understanding of the foaming process.

Sept 11, 8:00-12:00 — *Foaming processes* — Prof. Chul B. Park
Sept 11, 13:00-17:00 — Sustainable and composite foams — Prof. Hani Naguib
Sept 12, 8:00-12:00 — Nanocellular foams — Dr. Stéphane Costeux

FOAMS® 2018 conference

Held on September 13–14, 2018 at the Hyatt Regency in Montreal, QC, Canada is the premier forum for presentations of new developments in foaming technologies. The conference will feature presentations by leading researchers from industry and academia and student posters. Topics will cover foam processing, state-of-the-art foaming materials, micro or nano-cellular foams, environmentally-friendly foams, as well as foams properties and applications.

Social Program

Attendees will have the option to take part of a city tour / river cruise on September 12 and to attend a networking cocktail/award banquet on September 13.

Conference Chair

General Conference:	Marie-France Sosa, Plastiques GPR
	Xiaoxi Wang, The Boeing Company
Technical Program:	Stéphane Costeux, Dow-Dupont
Foams Tutorials:	Chul Park, University of Toronto

Conference venue

HYATT REGENCY

1255 Jeanne-Mance
Montreal, QC H5B 1E5, CANADA

FOAMS

4spe.org/foams2018

16th International Conference on Foam Materials & Technology, Co-sponsored by SPE Quebec Section & TPM&F Division

September 13-14, 2018

The Society of Plastics Engineers

FOAMS® 2018 Tutorial – September 11-12, 2018

FOAMS® 2018

Hyatt Regency Montreal, 1255 Jeanne-Mance, Montreal, QC H5B 1E5, CANADA Tel: 1 514-982-1234

(Room rate is CAD$253/night until August 1, 2018 (breakfast included/taxes not included) Mention SPE FOAMS® 2018

EXHIBITOR/SPONSORSHIP REGISTRATION FORM

Contact/Attendee: _____ Company: _____

Address: _____

City/State/Zip: _____

Phone #: (___) _____ Fax #(____) _____ Email Address: ***(please print legibly)*** _____

☐ *I wish to be a **Gold Sponsor for $2,500.00** (Includes tabletop, one complimentary registration, reception, company logo on poster and website, submission of logo on website, incorporation of logo in all pertinent advertising, announcement of Gold Sponsorship during conference, and submission of literature to attendees during registration process if desired.*

☐ *I wish to be a **Networking Cocktail Sponsor for $1,800.00** (Includes tabletop, one complimentary registration, announcement of sponsorship during Cocktail, company logo on poster and website, and incorporation of logo in any pertinent advertising.*

☐ *I wish to be an **Exhibitor for $1,500.00** (Includes tabletop, one complimentary registration, reception, company logo on poster and website, and incorporation of logo in all pertinent advertising.*

☐ *I wish to be a **Coffee Break Sponsor for $500.00** (Includes a tabletop, company logo on poster and website, and incorporation of logo in all pertinent advertising).*

☐ Please charge my Credit Card **$**_____

☐ Enclosed is my Check for $_____

Card # *(Amex/Visa/MC)* _____ **Exp. date** _____/_____

Authorized Signature _____ **Date:** _____/_____/_____

-Confirmation of Registration will be emailed once received. Set-up information will be emailed 2 weeks prior to the FOAMS® 2018 Conference.

Questions about Exhibiting/Sponsorship?

Email: Theresa Healy, Reedy Chemical Foam at thealy@reedychemicalfoam.com

(Ph: 980-819-6930 ex 114 Fax: 888-291-7290)

OR Daniel Marginson at dmarginson@plastic-age.com (Ph: 514-251-9550 x363)

Questions about Registration? *Follow link: www.4spe.org/FOAMS2018*

***Questions about the Conference**? Conference Co-Chairs: Marie-France Sosa, Plastiques GPR*

Email: m.sosa@plastiquesgpr.com Phone: 450-889-7277 and Xiaoxi Wang, The Boeing Company/Email: wang0213@gmail.com

Ph: 206-523-0555

All FOAMS® 2018 Exhibitor / Sponsorship Registrations must be made on/before August 16, 2018

E-mail I Registration Form to:

thealy@reedychemicalfoam.com -Theresa Healy, Reedy Chemical Foam & Specialty Additives

◆ 25 E. Front Street, Suite 200◆ Keyport, NJ 07735

– Or –

Fax/Email Exhibitor/Sponsor Registration Form & Credit Card payment to: Fax: 888-291-7290 thealy@reedychemicalfoam.com

❖ *SPE Website:* www.4spe.org/FOAMS2018

KEYNOTE SPEAKERS

2018 Outstanding Achievement Award – SPE TPM&F division

A half-century in thermoplastic foams

Jim Throne, Founder and owner, Sherwood Technologies Consulting, Dunedin, FL, USA

Jim Throne is the owner of Sherwood Technologies, a consulting company providing service on advanced plastics processing technologies. Before founding Sherwood Technologies, Dr Throne was employed by BF Goodrich and was a professor in Akron U. He holds Master and PhD degrees in Chemical Engineering from the University of Delaware.

From 10 bubbles to 10,000 bubbles across a human hair: Transparent Foams in Polyetherimid

Vipin Kumar, Professor of Mechanical Engineering, U. Washington, Seattle, WA, USA

Prof. Vipin Kumar leads the Microcellular Plastics Laboratory and is the Graduate Program Coordinator at the U. Washington. His professional interests lie in the areas of design and manufacturing, including product and process design. His research program focuses on microcellular and nanocellular polymers, a family of novel cellular materials expected to be used in a variety of applications in the decades to come.

Challenges and solutions in the recycling of polystyrene foams

Mario Grenier, V.P. & General Manager, Dyne-a-Pak Inc, Laval QC, Canada

M. Grenier holds degrees in Chemical Engineering and Business Management. He has worked in the petrochemical and plastic industry for over 31 years and, for the last 20 years, as General Manager of 2 Canadian plastic processors Wedco and Dyne-a-Pak, a leading producer of polystyrene foam food trays in Canada actively involved in foam recycling across North America

TECHNICAL PROGRAM

DAY 1 : Sept 13, 2018	
8:00-8:10	**Welcome**
8:10-8:50	**Keynote: Outstanding Achievements Award Lecture** Jim Throne, Sherwood Technologies (USA)
Session 1: Extrusion foaming process	
8:50-9:15	Design Considerations for Physical Foam Extrusion with CO_2 and N_2 Andy Caufman, Promix Solutions (USA)
9:15-9:40	Insights into the process and equipment to produce microcellular PET foams using extrusion foaming Daniele Tammaro , Sulzer Chemtech (Switzerland)
9:40-10:05	CO_2-assisted foaming of PLA by using a planetary roller extruder for an enhanced mass and heat transfer Judith Winck, Ruhr-University Bochum (Germany)
10:05-10:30	Morning break
Session 2: In-mold Foaming	
10:30-10:55	Advances in high performance thermoplastic foams Isa Fonseca, BASF (Germany)
10:55-11:20	Thermoplastic Sandwich Structures with Bead Foam Core – Novel Processing Approaches Volker Altstaedt, University of Bayreuth (Germany)
11:20-11:45	Thermal Properties and Morphology of Polyamide 6 Blends Foam Shu Kai Yeh, National Taiwan University (Taiwan)
11:45-12:10	Non-isothermal crystallization of hard segment in poly(ether-block-amide) (Pebax®) and the impact on foam injection foaming under N2 Ruosong Li, University of Toronto (Canada)
12:10-13:25	Lunch
Session 3: Chemical foaming agents and additives	
13:25-13:50	Chemical Foaming Agents: Foaming TPO in injection molding and extrusion Peter Schroeck, Reedy International (USA)
13:50-14:15	Chemical foaming of Copolyamide by reactive extrusion for automotive applications Mathilde Auclerc, University of Lyon (France)
14:15-14:40	Extruded PS foams nucleated by novel supramolecular additive to enhance foam morphology and properties Merve Demir, University Bayreuth (Germany)
14:40-15:05	Advances in Polyolefin Foaming Technology Colin Li Pi Shan, Dow Plastics (USA)
15:05-15:30	Afternoon break
Session 4: Foam structure and properties	
15:30-15:55	High Energy Return Foam of Thermoplastic Polyester Elastomers (TPEE) Andre Oosterlaken, DSM Engineering Plastics (USA)
15:55-16:20	Tailor-made polyurethane foam morphology for defined thermal conductivity Gisbert Riess, Montanuniversität Leoben (Austria)
16:20-16:45	Thermal properties of highly loaded piezo-composite foams Gayaneh Petrossian, Washington State University (USA)
17:00-19:00	**Reception / Poster session**
19:00-21:00	**Award banquet**

TECHNICAL PROGRAM

DAY 2: Sept 14, 2018	
8:00	**Welcome**
8:00-8:40	**Keynote: From 10 bubbles to 10,000 bubbles across a human hair: Transparent Foams in Polyetherimid** Vipin Kumar, University of Washington (USA)
Session 5: Nanocellular foams properties	
8:40-9:05	Developing Transparent Insulating Polymeric Nanofoam for Energy Efficient Window Application Jie Li, Argonne National Laboratory (USA)
9:05-9:30	Nanocellular polymers based on PMMA: Recent approaches to produce these materials with improved cellular structures and properties Miguel Rodriguez Perez, University of Valladolid (Spain)
9:30-9:55	Scalable process for the economical production of lightweight polymer nanofoams Roland Oberhoffer, Sumteq (Germany)
9:55-10:20	Morning break
Session 6: Nanocellular foams and fundamentals	
10:20-10:45	Low-density bimodal nanocellular PMMA/PVDF foams for super-insulating applications Guilong Wang, Shandong University (China)
10:45-11:10	Stress-induced cell size decrease in PMMA foams – the importance of hydrostatic stress in solid state foaming Angelika Beinert, Cambridge University (UK)
11:10-11:35	Graded and layered foams by gas foaming using periodic mass transport boundary conditions Ernesto di Maio, University of Naples (Italy)
11:35-12:00	Modelling Percolation Threshold of Conductive Polymer Composite Foams with Multi-cell Growth Chul Park, University of Toronto (Canada)
12:00-13:15	Lunch
13:15-13:55	**Keynote: Challenges and solutions in the recycling of polystyrene foams** Mario Grenier, Dyne-A-Pak (Canada)
Session 7: Sustainable foams	
13:55-14:20	Influence of Repeated Recycling of Polystyrene on Morphological Attributes during Solid-State Microcellular Foaming Abhishek Gandhi, CIPET, Bengaluru (India)
14:20-14:45	The effect of foaming on the biodegradation of poly (lactic acid) under controlled composting conditions Samir Shah, Scion / Biopolymer Network Limited (New Zealand)
14:45-15:10	Sustainable Nanocellulose Additives for Enhanced Polyurethane Foams Geoff Fisher, Performance BioFilaments Inc. (Canada)
15:10-15:40	Afternoon break
Session 8: Nano-composite foams	
15:40-16:05	In-Situ Shrinking Microfibers Enhanced Strain Hardening of Linear Polymers Patrick Lee, University of Vermont (USA)
16:05-16:30	Dispersion of carbon additives in styrenic polymer blends and its impact on foaming with CO_2 Anson Wong, Dow Specialty Products (USA)
16:30-16:55	Physical Foaming: A Facile Platform to Enhance Thermal Conductivity and Electrical Properties of the Polymer-Graphene Nanoplatelets Composites Mahdi Hamidinejad, University of Toronto / NanoXplore (Canada)
16:55-17:00	Conclusion and next conference announcement

HIGHLIGHTS FOR TPM&F BOARD MEETING

Meeting Date: May 9, 2018

ATTENDANCE

Attending the BOD meeting in person: *Dale Grove, Stephane Costeux, Shu-Kai Yeh, Chad Zheng, Xiaoxi Wang, Chul Park, Anson Wong, Sal Monte, Donna Davis, Perry Vadhar, Maxwell Wingert, Kim McLoughlin, Tim Weston, Chris Gagliano, and Gary Wilkes.*

Attendence on-line: *Ashu Sharma, N S Ramesh, and Ray Shute*

CHAIR REPORT – Xiaoxi Wang

Everything is running well for the TPM&F Division. A special thanks to the both the education committee *(led by Kim)* and membership committee *(led by Anson)* for their hard work.

BOARD MEMBER UPDATE

Chad Zheng has accepted position for Chair-elect.
Donna announced that all the six board members got re-elected for another 3-yr term.

COUNCILOR REPORT – Perry Vadhar

Finance Update – From 2017 Audit results, SPE plans to defer 1.5 MM Wiley bonus money over 10 years, starting in 2018.
ANTEC® 2018: 1500 registrations this year. There are 18% non-member, 23% students, 80% male, 15% non-English speaking, 41% first time ANTEC® and 36% age 21-34.
Total registration revenue is $576,345.
Pinnacle Award: Newly agreed method goes in effect starting June 1, 2018. You can submit any time during year and it is reviewed quarterly. You can submit max one application per category/ per calendar year. Please use an online submission form. The details can be found on The Chain. Brian Landes is looking for volunteers to serve on Pinnacle Award Standing Committee. This is a two-year commitment.
New Website: Launch of new SPE website and related function improvements. There is a strong positive feedback from volunteer leaders and membership. Membership lists now available on demand and downloadable. Improved functionality of the new website. Existing SPE microsite will be moved by May 31.
New ANTEC® Model: Jaime Gomez SPE VP Events, served as Task Group. A final presentation made to the EB in March. Two models are under consideration. Model 1 has three days event and Model 2 has four days. There is added second part for megatrends. ANTEC® TPC needs to be identified. The details of the new model will be posted on The Chain.

FOAMS® 2018 REPORT – Stéphane Costeux All planning for FOAMS® 2018 (Montreal) is going well. As of 5/5/2018, there are 3 keynote speakers; Jim Throne (OAA awardee), Vipin. Kumar (Univ. Washington) and Mario Grenier (Dyn-a-Pak). Already received 22 technical papers for the conference.

The tutorial program format is same as 2017. The presenters are Chul Park, Stéphane Costeux, and H. Naguib or Patrick Lee.

Budget planning indicated break-even point at 85 attendees for fee structure similar to previous years. Main expenses are hotel and food.

FOAMS® COMMITTEE UPDATE – Stéphane Costeux FOAMS® 2019 will be held in Spain on Sept 16-20, 2019. The Chair for the conference is Miguel Perez. FOAMS® 2020 location in the US is not finalized. The committee would like to determine a location and soliciting suggestion. There will be a need for a board member to Chair or Co-Chair the conference once location is selected.

MEMBERSHIP CHAIR REPORT – Anson Wong
Total membership has increased by 10 in April 2018 compared to February 2018 and 49 compared to October 2017. No report available for May 2018 yet.

A new membership reporting system should become available online in the next few days, and we will test and report our feedback when it becomes available.

Continue our free membership initiative for student attendees of TPM&F sponsored conferences. The list of international students from speakers of TPM&F sessions will be gathered for ANTEC® 2018 and they will be enrolled to the TPM&F Division.

continued on page 9

MEETING SUMMARY *continued from page 8*

SECRETARY/COMMUNICATION CHAIR REPORT – Theresa Healy

We need to incorporate SPE's new logo into all of our advertising materials. This new logo will need to be updated for our SPETPMF website as well as any other media channels/promotions that we do in the future. Theresa has already started the process of incorporating these changes to TPM&F website. Photos from the Polyolefins Conference have been uploaded and the newest information on the SPE FOAMS® 2018 Conference has been posted. Linked- In TPM&F site has 623 members in the group. Let's continue to keep it active so more people will join and participate.

TPM&F NEWSLETTER REPORT – Aaron Guan

The 4 issue newsletter model has worked very well for the past year and would like to continue that system into 2018.

Call for July 2018 Newsletter content will go out shortly after ANTEC®.

EDUCATION CHAIR REPORT – Kim McLoughlin

Chatterjee Travel Awards: Two students are selected. Both students presented at ANTEC® & will be reimbursed $750 each.

Salvatore J. Monte Scholarship: The name change is official with SPE HQ, and amount has been set to $4000.

Student Tour: A group of 8 Plastics Engineering students and 2 professors from Penn College recently completed their trip sponsored by our TPM&F Division. The two professors: Tim Weston and Chris Gagliano of the Pennsylvania College of Technology came to the board meeting and reported to the board on the touring event sponsored by TPM&F.

PlastiVan event sponsored in October 2017 in Pittsburgh which was combined with Braskem event. The site selected in October 2018 is Pittsburgh. We need to identify new opportunities and program coordinator for 2019.

U of Toronto Student Paper Contest: SPE Student Chapter at U of Toronto has created a contest for papers that will be published in our TPM&F Newsletter. TPM&F is sponsoring monetary prizes for winning authors. Papers have been submitted, and judging will start after ANTEC®.

STUDENT PAPER #1 MICROPLASTICS CAUSING A MACRO PROBLEM

Julia L. S. Bincik and Sabrina F. Cupryk,
University of Toronto, Toronto, ON

INTRODUCTION

From scientific journals to social media platforms, a recently emerging environmental and social topic is microplastics. The question is, why is enormous attention being focused on such small objects?

Microplastics, which are plastics less than 5mm in size, are common in everyday products such as toothpaste and face wash, and are also unintentionally produced from larger plastics breaking down [1]. The value of plastics in modern society cannot be contested; their versatile properties have resulted in them being one of the most widely used materials with a variety of applications [2]. However, it is becoming evident that if plastics are not created, used or disposed of in a sustainable way, the consequences of using plastics will soon outweigh the benefits. Due to the recent discovery of microplastics, and the limited research on their effects, their negative economic, environmental, and social impacts are still not fully understood.

In order to prevent the effects of unsustainable practices, such as the production of microplastics, world leaders and policy makers are making changes. The UN has developed seventeen Sustainable Development Goals, which are objectives for nations and industries to follow, in order to create a sustainable world by 2030 [3]. Microplastics are one of the challenges currently impeding the accomplishment of the goals related to health, water, sanitation, industry, and economic sustainability, as well as land and marine environment sustainability.

ENVIRONMENTAL SUSTAINABILITY

UN Sustainable Development Goals 14 and 15 focus on conserving both the ocean and land environment through the sustainable resource use [3]. Although the discovery of microplastics is relatively recent, scientists have begun to research their prevalence and effect on the natural environment [3].

From current studies, it was identified that at least 69 marine species have ingested microplastics [4]. One of these species is plankton, which form the foundation for the marine food chain. As a result, there are likely many more species affected by microplastics that have not yet been identified [5].

The two main effects of microplastics on animals is the transfer of toxins and their impediment on digestive tract functions [4]. The large surface area to volume ratio of microplastics enable them to leach more toxins, such as flame retardants, plasticizers, and antimicrobials into animals, compared to larger pieces of plastic [4]. As harmful bacteria can adhere to the plastic particles, they also act as a pathway for other toxins to enter marine animals [6]. The second main effect of microplastics is on the digestive tract of animals, causing inflammation and prolonged digestion due to retention of plastic particles [7]. Ultimately, this affects the amount of food an organism consumes, leading to an overall effect on their growth, survival and reproductive abilities [7]. One study found that marine worms exposed to microplastics had up to a 50% reduction in energy reserves [7].

The majority of research on microplastics' environmental impacts has been on marine ecosystems, with very limited research being done on their interaction with land ecosystems [8]. However, an estimated four to twenty-three times more plastic is disposed of on land than in the oceans [8]. Due to its high prevalence, microplastics' effects on soil composition, plants and animals is likely significant [8].

HUMAN HEALTH

Similar to the limited understanding of microplastics effect on land ecosystems, their impact on human health is not clear. The issue has only recently begun to receive attention and the lack of studies produced substantiates the issue. It is known that microplastics bioaccumulate as the particles pass through the food chain to reach humans [9]. A study done by the University of Ghent estimates that humans with a diet heavily reliant on seafood could consume 11,000 pieces of microplastics a year [9]. However, researchers are not yet sure how microplastics act once inside humans; whether they are absorbed by tissue or move throughout the body is unclear. While microplastics' ability to absorb other toxic chemicals has been proven, their ability to desorb these chemicals into the human body has not yet been verified [10].

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ECONOMIC SUSTAINABILITY

The consequences of microplastics on sustainability goals extend far beyond environmental and health impacts. A major concern for the plastic industry is the question of how to make plastics more economically sustainable. In the Sustainable Development Goals, the UN recognizes the necessity for industries to practice sustainable production and consumption methods. However, for the industry to meet these goals, which include "substantially reducing waste generation", serious steps must be taken [3].

Consider the plastic packaging industry. Currently the overall losses are valued at an astounding $80-120 billion USD a year; this is the loss for plastic packaging only, which accounts for just 26% of the overall plastic production [11]. Of the 78 million tons of plastic packaging produced in 2013, only 28% was recycled, 40% went to landfills, and 32% was released into the oceans [12]. This leads to additional costs, such as those spent to clean polluted areas, which amounted to approximately $75 billion in 2013 [12]. Other industries that rely on the marine environment are also impacted; losses in tourism and the fishing industry have occurred due to the high levels of water pollution [12].

The production of the plastics does not seem to be slowing; by 2050, the production of all plastics will make up 20% of total oil consumption [11]. If current practices are not improved, as the production of plastics increases, so will the economic losses created by the improper disposal and waste of the resource. Microplastics are especially difficult to reuse; once they reach such a small size, filtering and collecting the plastic becomes much more challenging, posing an even greater threat to the economy.

CURRENT FILTRATION TECHNOLOGIES

In order to tackle the issue of microplastics in water, new innovative solutions are being developed, such as adaptations to water filtration systems. Although wastewater treatment plants are 99% effective at removing microplastics, the sludge created by the plants containing microplastics are released back into the environment [2]. As a result, new technologies are being developed in order to reduce the amount of microplastics in effluents. Two examples are rapid sand filtration and dissolved air flotation, where small particles adhere to air bubbles and are removed through skimming [2]. The final technology, considered to be the most effective, are membrane bioreactors, which pass water through membranes with pore size of 0.4 micrometer [2].

Although the primary removal of microplastics occurs at water treatment plants, researchers are also looking for new ways to remove microplastics from the environment. Due to their small size, microplastics pose a unique challenge compared to regular plastic removal. To meet this challenge, researchers at the Monterey Bay Aquarium Research Institute are looking at mimicking plankton that spin a mucus web to collect its food, and also unintentionally collect and ingest plastics smaller than a grain of sand. The excreted plastics then sink to the ocean bottom along with the plankton's feces, allowing for easier collection [13].

PREVENTION STRATEGIES

In addition to removing microplastics from the environment, preventing the creation and waste of microplastics is necessary. There are various sources of secondary microplastics, which result from washing synthetic materials, abrasion of tires and disintegration of larger plastics [14]. Some efforts have already been made to reduce the creation of microplastics. For example, the USA Microbead-Free Waters Act of 2015 which banned the use of microbeads in cosmetic products such as toothpastes and soaps [15]. However, much more needs to be done to achieve the UN's Sustainable Development Goals.

Approximately two-thirds of secondary microplastic pollution is from abrasion of tires and fabrics, therefore this should be an area of focus for possible solutions [14]. Temporary solutions include limiting the production and purchase of synthetic materials such as polyester and nylon. Further preventive solutions include educating consumers on how to minimize the microplastics they produce. The average wash of a fleece jacket can release 250,000 fibres [5]. This number could be reduced by washing synthetic clothing less and at a lower temperature [16]. Unfortunately, there are currently no technologies capable of preventing the creation of secondary microplastics, but eliminating the production and consumption of plastics completely is unrealistic [17]. The development of new plastics that do not break down into microplastics will therefore be an important area of research for reducing microplastic production.

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CONCLUSIONS

Microplastics have only recently been identified as an issue, but because of their widespread usage, they have significant potential consequences on the economy, the natural environment, and human health. The situation is worsened due to limited research on microplastics' impact and therefore few solutions exist to filtrating and preventing the creation of microplastics. In order to meet the UN Sustainable Development Goals by 2030, a significant amount of resources must be devoted to research, as well as the development and implementation of solutions. Without taking these necessary steps to live sustainably, modern society's dependence on plastics will result in potentially severe and long lasting consequences.

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STUDENT PAPER #2 THE PUSH TOWARDS SUSTAINABILITY: THE IMPACT OF PLASTICS IN FOOD PACKAGING

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Plastics are hard to avoid in our daily lives. They have become so involved in our packaging industry, and it is easy to see why. Plastics provide benefits such as low density, transparency and good insulation, which are all important properties for materials used in food packaging. Plastics meet all of those objectives to help preserve food and extend its shelf-life. An interesting example of how plastics are used for helping the global food crisis is the Purdue Improved Cowpea Storage technology, where high density polyethylene and nylon bags are used to keep cowpea grains fresh for months, improving prosperity of farmers in African countries and preventing food waste [1]. However, issues such as improper plastic disposal and usage has plagued our oceans, contributing to 80% of marine pollution in the world [2] and using 4% of the global production of oil [3]. With 39% of the plastic produced in Canada being used for packaging [4], we must look for sustainable methods to support our society's needs while considering the health of our planet.

In today's society, many of our products are heavily packaged and disposable by habit. Products like disposable water bottles and single-use plastic bags are used regularly, and result in massive amounts of waste that need to be recycled or sent to landfills. Researchers have been hard at work, developing sustainable alternatives to the plastics that we use today in food packaging. There are numerous methods that sustainable materials can be created – they can be bio-based, easy to recycle or biodegradable/compostable, each with their own benefits. In addition, properties such as O_2 permeability and UV protection are desired in food packaging, and must be considered in material design for maximum impact in industry.

A new packaging solution is Ooho, an edible and biodegradable capsule made by a London start-up company called Skipping Rocks Lab. The Ooho is made of a thin membrane produced through spherification to hold water or other liquids. This seaweed-derived product is used as a replacement for polyethylene terephthalate (PET), an energy-intensive, petroleum-based plastic that is hard to break down. Compared to traditional PET bottles, the Ooho is biodegradable in 4-6 weeks, and uses 5 times less CO_2 and 9 times less energy [5]. The company is now working on mass production and commercialization, but have also shared the recipe through a Creative Commons license so anyone can make their own.

Edible food packaging is also a huge trend in academic research, and has led to the development of products derived from cow's milk. Using a protein in milk called casein, a plastic film was produced with excellent mechanical and thermal properties, while being lightweight and biodegradable [6]. This film can be used in single-use packaging like pouches, as a coating for cardboard boxes or even sprayed onto food instead of sugar coatings [7]. However, the product has not yet left the research stages. To make bio-based plastics successful, they must be easy to implement in current manufacturing facilities and economical to provide companies an incentive to switch from the petroleum-based plastic they currently use. It can be a challenge to adapt innovations from the laboratory into large scale production of consumer goods, but there has been some progress in this direction, with starch-based plastics like polylactic acid (PLA) slowly being integrated in commercial applications for packaging of yogurt [8]. If these innovative and biodegradable products can replace the traditional plastics used in food packaging, the amount of plastics in landfills can be greatly reduced.

The food packaging industry can also look to other sectors for inspiration to improve their sustainability efforts. A notable material category from the automotive and construction industry is natural fibre composites. By using natural fibres as a secondary material in existing plastic products, the usage of petroleum-based plastics can be reduced. Cellulose, the most abundant natural polymer on Earth, is commonly used as fillers in plastic to improve mechanical strength and reduce density. This is also an innovative method to increase sustainability and reduce the CO_2 that is being released to the atmosphere, since cellulose and other plant-based materials use the sun's energy to grow naturally, and store CO_2 by carbon sequestration [9]. As natural fibres are CO_2 neutral, they are a popular research topic in the plastics community. Combining nanoclays with natural fibres, a variety of different

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materials are currently being investigated to fulfill the desired properties of food packaging [10]. As research into greener plastics continues, materials with better performance will be developed to meet the needs of our growing population while reducing energy consumption and food waste.

As people become more aware of the environmental impact of plastic packaging, recycling and end-of-life treatment must be improved to meet the demand of our society. Green plastics have great potential to reduce the negative consequences of petroleum-based packaging, particularly for the food packaging industry. As we develop green plastics with improved properties and investigate new methods to produce and recycle our products, it will become easier to integrate these products into the society. Slowly, greener plastics will infiltrate the hold that petroleum-based products have on our lives and yield more sustainable growth in our future.

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