Volume 1, Spring 2023

Polymer Modifiers & Additives News

A Publication of Polymer Modifiers and Additives Division of Society of Plastics Engineers

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Chairman Message

First, let me thank you for being a valuable member of the SPE's Polymer Modifier & Additive Division. The PMAD division is striving to help our members grow in your respective areas along with sharing of technical knowledge in modifier and additive field. In doing so we also look towards giving back to the student communities through scholarships, awards, and recognitions. With your help we will continue to make a difference and achieve higher ground.

Going into the 2023 has been a challenging process for plastics industry and related businesses including academia. PMAD community has always been proactive in its intent to work through struggles that arise and this means that our division is resilient and has not slowed down! With your continued support we have been able to provide opportunities for networking and personal & professional growth through participating in vario;us industry events such as IPOC. One of our ongoing efforts is to increase our reach to a wider audience and I request you to share our newsletter with your colleagues and help spread the learning and success stories of our members.

We are also collecting fresh ideas for enhancing the cooperation and networking within PMAD community and our connected groups. One such thought is a more pronounced participation in upcoming conferences such as the Automotive TPO conference. We count on each person in our organization to support with papers and presentations to make it a success. # SPE-PMAD.

Another such thought is a virtual meet and greet with our group members, a networking event where you meet with your peers and board members. We welcome your recommendation if PMAD virtual meet and greet would be of significance to you and your colleagues.

In the efforts of continuous learning and sharing, I would like to welcome your suggestions and feedback, thoughts on ways to improve our communication and network. Please feel free to reach me directly at Anshuman.shrivastava@geon.com

Counting on your enhanced participation and ideas.

Sincerely,
Anshuman

Upcoming SPE Events

Automotive Composites Conference and Exhibition
Wednesday Sep 6– Friday, Sep 8, 2023
Novi, Michigan

SPE Color and Appearance Conference
Monday, Sep 18—Wednesday, Sep 20, 2023
Columbus, OH

SPE Automotive TPO
Sunday, Oct 01– Wednesday, Oct 04, 2023
Marriott Hotel, Troy, MI

SPE FlexPackCon
Tuesday, Oct 10— Thursday, Oct 12, 2023
Montreal, QC

SPE Vinyltec 2023
Tuesday, Oct 10– Thursday, Oct 12, 2023
Akron, OH

SPE Thermoforming Conference
Monday, Oct 23 - Thursday, Oct 26, 2023
Huntington Convention Center of Cleveland, Cleveland, OH

IPOC 2023 Recap

The 2023 International Polyolefin Conference (IPOC) theme was "GLOBAL POLYOLEFINS – Emerging Challenges for Sustainable Growth". The conference was held for the second year at the Galveston Island Convention Center, Galveston, TX. Total attendance was about 900, number of exhibitors 56 and 14 sponsors.

Conference technical program included 98 reviewed presentations, two tutorials, and five plenary lectures. Total 155 speakers. The student poster session had 19 posters.

Compared to two PMAD-hosted sessions in previous years, there is one more additive session added to this year's program, moderated by Dr. Hayder Zahalka. It brought up total 19 presentations focused on advances in polyolefin additives, mechanical recycling and flame retardants. The 2024 IPOC conference will again take place at the Galveston Convention Center on February 18-21. Wish you to see you all there!

Selected Paper Abstracts

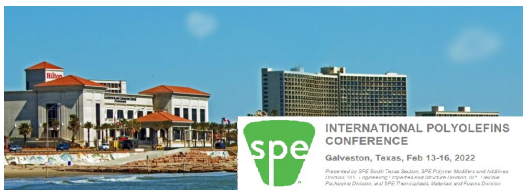
Enabling a Circular Economy: Carbon-Negative Fuel and Chemical Production by eliminating waste
— *Zara Summers, VP Science, LanzaTech*

The climate crisis is the most urgent challenge to mankind which can only be resolved via rapid action to drastically reduce waste carbon emissions. Carbon recycling technologies can transform above-ground carbon sources into sustainable fuel and chemical products. These technologies offer an industrial approach to both enable fuel and chemical manufacturing at its current scale, and achieve sustainability targets. Gas fermentation using carbon-fixing microorganisms is a fully commercial carbon recycling process technology that transforms waste carbon resources into sustainable fuels, chemicals and polymers at a scale that can be truly impactful in mitigating the climate crisis.

Compared to other gas-to-liquid processes, gas fermentation offers unique feedstock and product flexibility. The process can handle a diverse range of high volume, low-cost feedstocks. These include industrial emissions or syngas generated from any resource (e.g., unsorted and non-recyclable municipal solid waste, agricultural waste, or organic industrial waste), as well as CO_2 with green hydrogen. In the first instance there LanzaTech process is focused on the direct production of ethanol from these sustainable feedstocks. This ethanol can either be used directly as a blend stock in gasoline or dehydrated to ethylene for the manufacture of everything from sustainable aviation fuel to polyester resins, and surfactants.
Additionally, LanzaTech has developed a comprehensive synthetic biology capability for gas fermenting bacteria. This capability has enabled the company to demonstrate and, in some cases, scale the direct production of over 100 alternative chemical outputs from its gas fermentation process. One such molecule is ethylene, the most widely used petrochemical in the world with a $125Bn market. LanzaTech is pioneering the direct production of sustainable ethylene having already demonstrated continuous ethylene synthesis from CO_2 in its laboratory.

Novel PFAS-free Polymer Processing Aids for Polyethylene — *Zach Charlton, Ingenia Polymers*

Polymer process aids (PPAs) are widely used in polyolefin film applications to eliminate melt fracture, improve throughput and reduce die-lip build-up. The vast majority of current PAs are based on fluoropolymers. Fluoropolymers fall under the broad umbrella of PAS materials (per- or poly- fluoroalky| substances) which have come under increasing regulatory and market scrutiny. Performance data on newly commercialized PFAS-free PPAs are presented, including blown film time-to-clear, cast film die lip buildup and rheological data. Application to downstream film converters via masterbatch, and to resin production via incorporation in an additive pre-blend are presented.



INTRODUCTION TO ADDITIVES & MODIFIERS FOR PLASTICS

Contributed by Dr. Ashok M. Adur, President & Consultant, Everest International Consulting (LLC), Jacksonville, Florida,

Today more than ever, plastics have become an irreplaceable part of our living. There are many different plastics because each has its own unique set of properties that make each one particularly suited to a certain application. Theoretically, it might be possible to make a new plastic for each application, but in reality, doing so will certainly be far too expensive and difficult. Instead, the preferred method is to use additives and modifiers which, when blended into an existing product, allow the skilled formulator to fine-tune the properties specifically for each desired application. Almost every application one or more additives and modifiers need to be added to the plastic. Rarely is a polymer used without any of these additives. From both technical and commercial perspectives, these additives are a large, significant and critical part of the polymer industry with annual global sales estimated to be over $50 billion, whether for plastics or rubber/elastomers. Colorants, fillers, reinforcements, plasticizers and other additives and modifiers are added to the polymer formulation to improve its use either for appearance, performance, improved processability, or lowering cost, or a combination of these reasons. Such additives are essential in order to meet various customer requirements all the way downstream in the value chain as the plastic is processed into pellets, converted to the final form, shipped, warehoused, used in the application till the product is used and reaches the end of its utility. Using plastics is all about finding the right balance of properties and at the right price. When using additives to improve plastics, one must be aware of the changes that occur in other properties and how to maximize the benefits while minimizing the negatives.

[We will feature an article in each issue of our PMAD newsletter for the foreseeable time. The intention is to spread information without promoting any specific supplier or brand name by knowledgeable experts who are active in PMAD.] This is the first one in this series and will provide an introduction of various types of these additives and their purpose. Subsequent articles in future issues will cover one or more of these types with specifics of which plastics benefit from each type and why the particular chemistry of the additive makes it useful, along with some data.

There are many ways to classify these chemicals, but the common way is to do so by their utility. Based on this here are the most common and a few specialty types

Heat and Light Stabilizers

Different polymers have varying degrees of heat and light resistance based on their chemical structure, molecular weight and crystallinity. Stabilizers are added to almost every type of polymer whether a plastic or a rubber. Heat stabilizers protect the properties of the overall compound from heat damage, either during the manufacturing process and/or during normal use of the finished product. Similarly light stabilizers help to protect the plastics compound from light, particularly ultraviolet light. These stabilizers help prevent degradation of plastics to preserve the polymer's appearance, strength, elasticity, durability and performance characteristics. The reason why prevention of degradation from heat and light need to be handled simultaneously is because the degradation mechanism for both is similar, typically due to chain scission and free radical formation. One or more additives in a typical stabilizer package can address both causes of degradation. Light stabilization typically also involves the use of a light absorber in addition to an additive that reacts with free radicals to inhibit their propagation. Some plastics contain catalyst residues and may also need catalyst deactivators as part of the stabilizer package.

Colorants & Optical Brighteners

Colorants and optical brighteners can be compounded into the plastic compound to provide color using liquid colors or solid pigment colors in powder or masterbatch form. Ideally colors must be chemically compatible with the plastics matrix, otherwise needing the use of dispersants. Care should be taken to ensure that the color used is stable and retains its color for all potential conditions that the colored

plastics part is used all the way downstream. Such conditions include heat, ultraviolet light, moisture, chemicals, solvents, etc. to ensure color fastness and avoid migration, fading and change of the colored plastics.

Impact Modifiers

Obviously impact modifiers are used to improve impact properties of plastics. However, selection and loading level of impact modifiers in plastics has to be implemented correctly to optimize all of the mechanical, thermal and other properties as well as cost. Impact modifiers typically also help with making plastics products less brittle, more flexible and increasing stress crack resistance. In many plastics the particle size distribution of the impact modifier in the impact-modified plastics matrix also plays a part in the effectiveness of the improvement in its impact strength and may also affects its melt viscosity. Optimization of particle size of the impact modifier is critical in many impact-modified plastics. Another factor to remember is that the improvement in impact strength is not always proportional to the loading level of the impact modifier. Also, chemical compatibility and even covalent bonding in such multi-phase systems provides significant improvement in the effectiveness of impact modifier.

Plasticizers, Flow Modifiers & Other Processing Additives

Depending upon the specific plastic resin and its molecular weight, its processing may need the use of flow modifier additives either to increase flow and reduce melt viscosity or in some cases to reduce flow and increase melt viscosity based on the type of downstream process that it is destined for. To increase flow, a plasticizer that has a similar solubility parameter (a measure of chemical compatibility to the matrix polymer) is used. Use of a plasticizer is also critical for a polymer where the thermal degradation temperature is lower than its melt and particularly its processing temperature. In a few specialty cases an additive that provides increased lubricity is used in processing ultrahigh molecular weight HDPE. In some rare cases, even an additive that chemically reduces molecular weight is used to increase flow sufficiently can be used to increase production rates for downstream processes like powder coating or roto-molding, as long as it does not detract from reducing its mechanical properties. With other plastics one might need to add chain extenders to increase its melt strength to enable it to be become processable like in processes like thermoforming, especially to improve deep draw.

Flame Retardants

While a few plastics are inherently flame resistant, most others need flame retardant additives to minimize the propagation of smoke and flames. For a fire to begin, fuel, oxygen, and an ignition source must be present. Flame retardants work by interfering or eliminating one or more of these key ingredients, either physically or chemically. Flame retardants are chemical compounds added to plastics in order to prevent, delay, or slow down combustion, reduce smoke formation, and/or prevent the material from melt collapse (anti-dripping). These additives are common in numerous everyday products to avoid the ignition and burning of plastics. Flame retardant (FR) plastics are essential to devices we use every day, providing a valuable tool in fire prevention, but their technology is complex. Typically based on the requirement of the end use application, it is necessary to meet specific performance criteria, specified by government and/or industry regulations. Plastics parts may need to pass such as burn time, extinguish time, flame spread, smoke development, and/or retention of mechanical properties. Some requirements may specify that they do not contain halogens or do not generate smoke as well. It is important to remember that the design, shape, and surface area of the part also play a critical role in combustion.

Fillers & Reinforcements

While a large proportion of plastics are processed with additive content at a low level of below 1-2% and even lower for transparent films and sheets, other applications need fillers and reinforcements at higher loading levels either to lower cost and/or increase the range of performance for that application. In some cases, these types of additives provide additional benefits: 1) increase thermal resistance by increasing heat distortion temperature, 2) improve resistance to permeability giving the permeant a more tortuous path and improved barrier properties, 3) increase either thermal or electrical conductivity or both, 4) increase sound absorption to reduce noise, or 5) increase or reduce specific gravity of the compound increase or reduce specific gravity of the compound significantly.

When using fillers and reinforcements, it is important to consider particle size, particle size distribution, and their aspect ratio and orientation (when the filler or reinforcement is non-spherical) in the final part because these three factors have a significant effect on the mechanical and other properties of the plastics compounds or composites and in most cases the processes of compounding, extrusion and molding reduce these factors. In many cases to enhance and optimize performance, it may be necessary to also use coupling agents and/or surface modification of the filler and reinforcement for optimizing performance.

Additives for Modifying Specific Gravity of Plastics

Two common methods to reduce specific gravity of a plastic part involve either using foaming agents to get a foamed plastic past or using hollow beads also called microspheres (typically produced from glass or certain rigid plastics). When foaming agents are used the important factors to consider to achieve a targeted specific gravity are the temperature at which the foaming agent gives off its gas, its loading level in the plastics and the process temperature for both foaming and the cooling cycle. For hollow microspheres which can go down to a specific gravity of 0.025 g/ml. and range from 12 to 300 micrometers. To the naked eye, the small, hollow spheres will appear like fine powder.

Each type has its own upper temperature limitation. in addition to reducing density of plastics parts, such microspheres also provide many product enhancements and process improvements, including improved dimensional stability, increased impact strength, smoother surface finish, higher thermal insulation, easier machinability, faster cycle times, and cost savings. Similar to compounds produced using other fillers and reinforcements these microspheres can benefit from achieving interfacial adhesion to the matrix polymer using coupling agents and surface modification of the filler.

Some applications might need very high specific gravity compounds. In such cases, a filler with very high specific gravity is compounded in at the dosage level to achieve the required specific gravity required for that application. Such fillers are usually oxides of heavy metals.

Coupling & Compatibilizing Agents:

Plastic resins are macromolecules, meaning they have long chains with high molecular weight compared to most other chemicals and each one is different from another. Some plastics are also crystalline. Hence when other materials are added to the formulation beyond a small percentage, typically what results is a multi-phase system, which can result in poor interfacial adhesion between those phases and variable properties based on its processing. To overcome that and achieve an optimal compatibilization, modifiers are added to provide such interaction, which can be classified as one of the following types: hydrogen bonding, ionic bonding, co-crystallization, associative bonding, or covalent bonding. Compatibilized polymer alloys and composites show superior performance compared to a mere blend of the two polymers. Various microscopic techniques and data measured before and after compatibilization have been used to show that these modifiers result in better dispersed smaller particle sizes of the dispersed phase with improved interfacial adhesion, which can transfer stress effectively from the matrix to the dispersed phase. Optimization of selection of the right modifier, its loading level and processing are all necessary for the best outcomes. Generally, these modifiers have one end of their molecule that interacts with one of the phases while the other interacts with the other. When two polymers are mixed in, they are called compatibilizers while when fillers and reinforcements are used to form composites, these additives are called coupling agents. Another application where this type of interfacial bonding is used extensively is for multi-layer co-extrusion and lamination, used in packaging and other applications.

Surface Property Modifiers

Some applications need surface property modification using additives that can migrate to the surface. In some cases, the formulation may include additives to enhance migration. Some specialty additives are formulated to improve scratch and mar resistance. Examples of other surface property modifiers include: 1) Additives that improve surface properties like gloss and leveling, support brilliance and color intensity 2) Anti-block additives that address the stickiness between layers of extruded film. 3) Additives that improves adhesion. One specific example is where an adhesive is

used with much lower level of adhesion to obtain peelability. 4) Other additives that are used for obtaining release performance, where the opposite of adhesion is needed in adhesive films and papers, used in many different end use markets. 5) additives that help the part resist degradation from specific chemicals or solvents. 6) Specialty additives are used in marine applications to prevent or at least minimize adhesion of barnacles.

Permeability Modifiers

For some applications it is important to reduce permeability of plastics to oxygen, moisture or flavor. Some specific impermeable fillers and reinforcements can be used to achieve this goal. This includes mineral fillers, especially those that can provide a more tortuous path for the permeant, due to their inherent morphology. Other approaches to achieve the same objective is to use particles of various shapes or add other plastics with good barrier properties that when optimally dispersed also provide a tortuous path. The tortuous path approach can only reduce the permeability rate but cannot act as a permanent barrier.

Nucleating and Clarifying agents:

Nucleating agents can help to initiate crystallization and modify crystallization rates. To obtain clarity of the plastic article, clarifying agents are used, which work on the same principle as nucleating agents but create multiple initiation sites for crystallization very quickly to ensure that during the colling stage, the crystallization process, a multitude of tiny crystals are formed, keeping the crystal size below the wavelength of light and creating a more transparent article.

Anti-microbials and anti-pest additives:

There are many different types of antimicrobials used in plastics. These include additives that anti- bacterial, antifungal, anti-viral, anti-rodent, anti-insect and other specific undesirables. It is important for use in most plastics to ensure that such additives do not leach out but also that they come to the surface of the plastic part.

Additives to Deal with Taste, Odors & Moisture

A unique type of additive that is gaining increasing acceptance is the use of specialty additives that modify or impart specific taste to plastics. One example of this is the use of non-toxic, non-migrating bitter compound added to plastics to prevent rats from biting into plastic parts, especially electrical wiring. Such anti-rodent additives have the benefit of being environmentally friendly.

For some applications, it may be necessary to include specialty additives that address the need to deal with odors or absorb moisture. Odors are a constant problem when working with post-consumer plastics. Most plastics that are recycled, such as PE, PP, PS, PVC or PET, are subjected to a washing step with aqueous solutions to remove contaminants. But odors trapped inside the recycled resins may linger. Two types of additives are used to deal with odors. One way is to mask the odor with a stronger pleasant odor to neutralize the original foul odor. This might work in some applications where the fragrance may be sufficient to mitigate the odor. The other option is to incorporate an odor absorbing additive in the plastic formulation. These additives act by trapping the organic odor-producing molecules within their highly porous crystal structures, such as molecular sieves, activated charcoal, high-surface-area silica and zeolites. Molecular sieves also work to absorb moisture as do some anhydrous oxides and salts. All of these can be compounded into the plastic formulation. If the odor is due to microbials, an anti-microbial also works to mitigate/eliminate the odor.

Additives for Recycling & Sustainability:

As stated in the paragraph above, odor issues with post-consumer recycled plastics can be addressed with odor-absorbing additives. Other methods to remove odor include either solvent or carbon dioxide extraction. Many of the other issues with recycled plastics that degrade due to hydrolysis like polyesters and polyamides. The remedy to regain molecular weight and increase their viscosity and mechanical properties is to compound such recycled plastics with chain extenders. Other specialty additives that help with but are not a panacea for sustainability include additives that degrade plastics by initiating chain scission. Yet there are companies that sell such additives. For many applications, it may be necessary to process recycled plastics use other additives that have been covered in earlier sections of this article, like anti-oxidants, UV stabilizers, flame retardants and plastici-

-zers in order to meet customer or regulatory requirements. To improve performance properties of mixed plastics, it may be necessary to use compatibilizers.

Our SPE's Polymers Modifiers & Additives Division (PMAD) covers the vast range of additives and modifiers used in all plastics for almost all plastics processes and the extensive range of applications and end markets. One of our missions is to share information to our members. This article is a new effort towards meeting that goal. Future newsletters will have more articles detailing one or more of these modifiers and additives.

ANTEC 2023 Recap

This was a year when both international polyolefin conference (IPOC) and ANTEC took place in the same month. And both of the conferences turned out to have great attendance. Two weeks after IPOC, ANTEC® 2023 attracted some 500 registered attendees in Denver, approximately twice the registered turnout of last year's conference in Charlotte. The event was the second in-person ANTEC since the pandemic forced virtual presentations of the annual gathering in the past two years.

The conference also attracted close to 300 papers for presentation and the sources of the papers were also more diverse. ANTEC usually attracts research-intensive papers from academia, government laboratories and other specialized sources. Since organizers have been working to broaden submissions from industry, the papers coming from industry accounted for 40 percent of the total this year.

For more information and download conference proceedings, please visit ANTEC® 2023 | SPE (4spe.org)

2023 PMAD Scholarship

Polymer Modifiers & Additives Division (PMAD) offers scholarship (PMAD Challenges) to graduate or undergraduate students with experience in the PMAD industry who can document their experience including courses taken, research conducted, or jobs held.

In the past five years, PMAD has awarded 36 individuals totaling $50,000. We hope our investment and commitment could encourage you to continue making differences in the plastics world through your study and research, and to build good foundation to your professional careers.

The acceptance of PMAD Scholarship for 2023 started at the same time as other SPE foundation scholarships, which was December 1st, 2022, and ended on April 1st, 2023. PMAD education board will review all the applications and announce the scholarship recipients in our Fall newsletter. If you have the interest to apply PMAD Scholarship, please come back to the SPE website towards the end of the year in December, when the application portal opens: https://www.4spe.org/i4a/pages/index.cfm?pageid=3313

Messages from Selected 2022 PMAD Scholars

"I would like to thank the Polymer Modifier & Additives Division for selecting me as this year's recipient of the SPE PMAD Scholarship. I chose to attend Notre Dame because I knew the education I would receive would cultivate both my mind and my heart; I also knew a membership at SPE would help me develop critical skills to apply in the polymers industry. I am exciting to get to use the knowledge that I have learned in my polymer research at school in such a large-scale industrial application. The funds of this scholarship will go directly to paying for my tuition and will allow me to relieve financial stress while focusing on finishing my chemical engineering degree."

— Madison Pixler, Univ. of Notre Dame

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Did you know that PMAD is on LinkedIn? To promote informal member communications, the Polymer Modifier and Additives Division® (PMAD) of the Society of Plastics Engineers has embraced social media and maintains a Group Page on LinkedIn . PMAD's Group page provides an easy-to-use forum for professionals working in the field of polymer modifiers and additives to gather on-line, share information, network, and collaborate. We currently have 262 members, the group is growing, and for those who have not already joined we encourage you to become members and participate in the discussions. We also use our LinkedIn page to provide announcements of PMAD activities. Our LinkedIn group address is https://www.linkedin.com/groups/3306225/. Check us out!

CALL FOR PAPERS/Deadlines

Here is a kind reminder of call-for-paper notice from coming events. Please check it out and submit your abstract and/or paper in time for your favorite conferences or scholarship programs!