



Dear SPE Color and Appearance Division Members,

Welcome to the Winter edition of CAD NEWS! On behalf of the entire division, I would first like to thank Scott Aumann for organizing another successful CAD RETEC® last fall at the Sawgrass Marriott Resort and Spa in Ponte Vedra, Florida. Over 425 people attended the conference “Driving Color into the Future”. We appreciate the support of the twenty-two corporate sponsors that contributed to the event, and the 2016 Fun Run generated \$1840 in donations for Habitat for Humanity.

The technical program co-chaired by Mike Willis and Betty Puckerin featured twelve technical papers pertaining to extrusion, colorants, special effects and quality control. We had the pleasure of hearing from five key note speakers including William DeVos of SPE, Dr. Weiping Yu of NASA and Greg Autore of Purple Suit. Sandra Davis once again hosted the New Technology Forum highlighting new products and technologies from exhibitors. The audience was also able to participate in an interactive panel discussion regarding Regulatory Topics for the World of Color.

I would personally like to thank all of the volunteers on the 2016 CAD RETEC® committee for offering their time and expertise to organize such a successful event. Events like our CAD RETEC® take a tremendous amount of planning behind the scenes to ensure that the event runs smoothly.

As we speak, the 2017 election for Board of Directors is underway. I encourage all of you to visit the election portal on our website at www.specad.org. There you will find the ballot and biographies of all the candidates. Nine board members will be elected to serve a 3 year term. The election will end on February 28th, so please be sure to cast your vote.

Table of Contents

Chairman’s Letter	1
Editor’s Note	2
Election – Please Vote!	2
CAD RETEC® 2016 Recap	3-4
Preliminary CAD ANTEC® Program	5
Sponsorship Page	6
Invitation to Attend our Meetings.	7
CAD Meeting Minutes Reference	7
About Newsletter Sponsorship	8
What’s Brewing with Color? RETEC®2017	8-10
Outstanding Achievement Award	11
Councilor’s Report	11
Connect with Social Media	11
Scholarship Opportunities	12
Sponsorship Page	13
Technical Article	14-17
Officers & Directors Listing	18

The next event for the Color Appearance Division will be the 2017 Society of Plastics Engineers ANTEC® May 8 -10 in Anaheim California. The Color and Appearance technical sessions will take place on Monday, May 8th. We look forward to seeing you all there.

Following the technical sessions at ANTEC®, we will hold our next Board of Directors meeting on Tuesday, May 9th. All members are welcome. Please just contact me or another Board Member if you would like to attend.

I would like to close with a special thanks to entire Board of Directors team. They are the most dedicated team of professionals I have ever had the opportunity to work with.

Thank you all for your continuing support of the Color and Appearance Division. I look forward to seeing you all in Anaheim!

Best Regards,

Brenda Mullins
2016-2017 SPE CAD Chair

2017 Winter Newsletter Editor's Note

Welcome everyone to 2017 and hopefully it has gotten off to great start for you. As we head in to 2017 the Newsletter will once again be offering ads to show off your company and allow others to see the heart behind Color and Appearance. These sponsorship ads allow us to do these Newsletters and help maintain a solvent division of the SPE and allows us to keep getting pertinent information out to the division members. See page 8 in this Newsletter for the different sizes available and for contact information. Sponsorships will run from winter issue through the fall issue, if content is available, with a minimum of three Newsletters being published.

In this Newsletter, you will find various bits of information about the Color and Appearance Division, what it's doing, where we are going and where we've been. You find our Councilors report letting us know what the SPE is up to and some of the issues pertaining to them. You will find technical presentations from past RETEC® and or ANTEC®. Recap of last year's RETEC® and your Board of Directors information and your opportunity to vote who should be on the Board of Directors. Voting will be open until February 28th so get to the website and cast your vote. You will find information about Scholarship opportunities from the Color and Appearance Division. Here you will also find information about this year's ANTEC® in Anaheim and RETEC® in Milwaukee.

Hopefully there is something for you in the Newsletter and as always if you have any suggestions or comments please me or someone on the BOD know.



Mark Tyler
Newsletter Editor



2017 Board of Directors Elections (2017-2020 Term) Society of Plastics Engineers – Color and Appearance Division Voting will be open from February 1st and to February 28, 2017

ABOUT THE CAD BOARD OF DIRECTORS:

The Board of Directors is the governing body of the Color and Appearance (CAD) Division of SPE. The Division Board of Directors is composed of 27 elected Directors, the Council Representative (Councilor), and the 5 Division officers, for a total of 33 positions on the board.

SPE CAD is a volunteer organization. Board members are chosen by election.

Members of the Board participate in the planning, organization and running of CAD activities including ANTEC® programs, RETEC® programs, Technical Programs, Scholarship Programs & Funding, as well as offering guidance and advice to other SPE members interested in coloring plastic resins.

TERM OF SERVICE FOR THOSE ELECTED:

Each CAD Board Candidate serves a three year term, beginning at the close of ANTEC® following the election. CAD requires all of its Board Members to actively participate in Board activities including attendance at ANTEC® and RETEC® and the four planning meetings held annually. This year's nominees are running for a term beginning in 2017 and ending in 2020.

Be sure your vote is counted. Voting ends February 28th

If there are any questions about this election, please contact the Elections-Chair [Cheryl Treat](#) by email or by phone @ 419-217-0862.

[CLICK HERE TO GO TO ELECTIONS PORTAL](#)

CAD RETEC® 2016 Recap

What another great success. The Color and Appearance Division of the Society for Plastics Engineers (SPE CAD) were able to bring together designers, colorists, color engineers, color scientists and academics from around the world. I hope that all expectations were met and value was realized for the 2016 RETEC® in Ponte Vedra, Florida. With Two full days of technical sessions, 65 exhibitors showcasing their products and services, Excellent Networking Opportunities / Receptions, New Technology Forum and Interactive Panel Discussion, the 2016 SPE CAD RETEC® had something for all.

I am very thankful for all the support I have received from all the CAD members over this past year and every year as we move into 2017. This year, like all others, was made possible by all the behind the scenes activity by my committee members. I would also like to thank all the Sponsors who make it possible for us to continue to produce a quality conference that will meet the changing needs of the society at below the industry costs for a conference of this magnitude.

I especially want to give a huge thank you to all those who were in attendance and who support this annual conference year after year.

Scott Aumann
2016 CAD RETEC® Chairperson

**SPE CAD RETEC® at the Sawgrass Marriott Resort in Ponte Vedra Beach, Florida
September 11th – 13th, 2016.**



End of Conference Raffle–Giving away donated prizes to the ones that stay until the very end: Scott, Cheryl and Betty putting on a show.

CAD RETEC® 2016 Recap



PLATINUM SPONSORS



CAD RETEC® 2016 Committee

- Chairperson: Scott Aumann, *EMD Chemicals*
- Vice-chairperson: Mark Tyler, *Celanese*
- Technical Program Co-Chairs: Mike Willis, *Sun Chemical Company*
Betty Puckerin, *Ampacet*
- Exhibitors: Brian West, *Techmer PM*
- New Technology Forum: Sandra Davis, *The Chemours Company*
- Panel Discussion: Betty Puckerin, *Ampacet*
- Registration: Bruce Mulholland, *Celanese*
- Sponsorship: Cheryl Treat, *A. Schulman*
Mark Freshwater, *LANSCO Colors*
- Printing: Sharon Ehr, *Uniform Color Company*
- Publicity: Betty Puckerin, *Ampacet*
- Website: Jeff Drusda, *Silberline*
- Fun Run/Walk: Bruce Clatworthy, *Dominion Colour Corporation*
- Raffle: Cheryl Treat, *A. Schulman*
- Golf Outing: Mark Tyler, *Celanese*



GOLD SPONSORS



SILVER SPONSORS





**PRELIMINARY TECHNICAL PROGRAM ANTEC® 2017
COLOR AND APPEARANCE DIVISION**

MORNING SESSION

TIME	TITLE	AUTHOR
8:00	Color Theory	Bruce Mulholland
9:00	A Systematic Approach for Color Matching Material that Contains Effect Pigments	Breeze Briggs
9:30	Effects of Processing Parameters on Colour Variation and Pigment Dispersion During the Compounding	Jamal Al sadi
10:00	Processing Mica Based Pigment Masterbatch	Rob Roden
10:30	Exploring Powder Treatments to Improve Filler Incorporation for Optical Compounds	Erin Keaney
11:00	Color Computers, not just a Pass/Fail Tool Anymore	Frank Koger

AFTERNOON SESSION

TIME	TITLE	AUTHOR
2:00	Color Pathways Through Time	Doreen Becker
3:00	Custom Polymeric Diffusors as Highly Efficient Substitutes for Conventional Pigmentary Scatterers in LED Lighting Technology	Arno Boehm
3:30	Hacking Masterbatches	Francis Rodrigues
4:00	Surface Aesthetics: Resolving Appearance Defects in Injection Molding	Eileen Gallihugh
4:30	CAD Annual Business Meeting	

Your Idea. Our Solution.™

Organic & Inorganic Pigments and Preparations



Dominion Colour Corporation
Your Idea. Our Solution.™

ISO 9001
ISO 14001

1-416-253-4296 sales@dominioncolour.com www.dominioncolour.com



Ron Oberstar, President
tel 847.429.9791
cell 440.376.1642

CONTACT US FOR THE FOLLOWING:

- Solvent Dyes
- Anti-Oxidants
- Lubricants - Stearates
- UV Absorbers
- Liquid + Dry Mixing and Milling Process Equipment
- Waxes and Hardeners
- Lightweighting Materials

"Fortune Favors the Brave"



NOW SERVING: FOOD CONTACT COMPLIANT FLUORESCENT COLORANTS FOR PET

WWW.DYES.COM



We are experts in the coloring of Plastics.

We will find answers, resolve problems, make cool things happen, and bring innovations to improve your products and applications.

1-800-522-4DYE

Custom Masterbatch Solutions
High-Performance Custom Compounds

Telephone: 865.457.6700 www.techmerpm.com

Ti-Pure™

Leading innovation and solutions for all your plastics needs.

Chemours, proud supplier of Ti-Pure™ titanium dioxide.

© 2017 The Chemours Company TT, LLC.

suc•cess [sək-'ses]
performance; appearance; processing; surface solutions for packaging

Our definition of success is helping you achieve yours.

www.aschulman.com

The Shepherd Color Company

We Brighten Lives

4539 Dues Drive
Cincinnati, OH 45246
Tel: 513-874-0714

Complex Inorganic Color Pigments
IR Reflective Pigments
Special Effect Pigments

salesusa@shepherdcolor.com
www.shepherdcolor.com

Invitation to Attend Our Board Meetings

The Color and Appearance Division regularly holds Board of Director (BOD) meetings at the ANTEC® and the CAD RETEC®. In addition, a Summer BOD meeting is typically held about 6 weeks prior to the next CAD RETEC®.

The Summer meeting is scheduled in various locations. A Winter BOD meeting is held in January. The Winter meeting is typically held at a site of a future CAD RETEC®.

Any SPE CAD members who wish to attend are welcome at these meetings. If interested in attending the next Board meeting, please contact the Division Chairperson for more information.

Board Minutes

The CAD Division posts the board minutes as soon as approved and they are accessible on our website.

[Click here](#) to review our board minutes.



Color and Appearance Division

TOMATEC Tokan Material Technology Co., Ltd.

Leading Manufacturer of Complex Inorganic Color Pigments (CICP)

- Pigment Brown 24, Yellow 53, Blue 28, Green 50, Black 28, etc.
- Environmentally Friendly Pigments; Brown 48, etc.
- Laser Marking Pigments

Contact in Americas:

TOMATEC America, Inc.

7914 Tanners Gate Lane Florence, KY. 41042

TEL: (859) 746-0407 FAX: (859) 746-0467

tomatecpm@tomatec.com

WWW.TOMATEC.COM

uV Stabilizers

iD Additives™ UV Stabilizer Systems have been tailored with Hindered Amine backbones to provide greater durability to meet the increased demands of widely ranging applications where UV Exposure is expected. They have proven their ability to outperform standard Hindered Amine UV Products in both PE and PP in the following applications:

- Color Concentrates / Masterbatches
- Wood Composites / Roofing / Pipe
- Outdoor Furniture / Stadium Seating
- Film for Chemically Aggressive Applications

iD Purge

iD Additives™ is proud to introduce the iD Purge purging compound which delivers the following benefits to your company and bottom line:

- Reduces resin required to purge
- Works with ANY RESIN - No need for multiple grades
- No harsh chemicals. Non-Flammable. Non-Abrasive.
- FDA Compliant and environmentally safe
- Minimizes process equipment down-time
- All natural ingredients



iD Additives™
unmatched technical support
for innovative products

www.iDAdditives.com

info@idadditives.com



About 2017 CAD NEWS® Sponsorships

Mark Tyler, the CAD Newsletter Editor, publishes at least (3) issues of the CAD Newsletter per calendar year. This publication is e-mailed to approximately 1,000 Plastic Color Industry professionals and is also posted on our website at <http://www.specad.org/> and also the Parent [SPE website](#) on the Divisional pages

In addition, the newsletter is posted on the Society of Plastics Engineers website technical area. Three (3) issues appear in electronic form annually and each sponsor placement is automatically linked directly to your website when the viewer clicks on your ad, provided you supply us with your website address. Participating in a sponsorship in the CADNEWS® is a great way to connect with plastic coloring industry professionals by promoting your company and the services you offer.

OPTIONS	HEIGHT X WIDTH
1-unit	2 x 3.5
2-unit	4 x 5
3-unit	6 x 3.5
4-unit	4 x 7.5
1/2-page	5 x 7.5
Full page	8.5 x 11

If interested in learning more, please contact:

Brian West (865) 425-2113 bwest@techmerpm.com

Mark Tyler (419) 217-0862 mark.tyler@celanese.com



Brilliant Plastics: Make Things Desirable

Unique sparkle in combination with high chroma and colour purity – these are the outstanding characteristics of the transparent LUXAN pigments. In the interior of automobiles, LUXAN pigments give sparkle and luster to high gloss jet-black plastic components. ECKART is one of the world's leading manufacturers of metallic pigments for the plastics industry.

For further information please contact:
ECKART GmbH · Guentersthal 4 · 91235 Hartenstein · Germany
Tel +49 9152 77-0 · Fax +49 9152 77-7008 · info.eckart@altana.com · www.eckart.net
ECKART America Corporation · 4101 Camp Ground Road · Louisville, Kentucky 40211 · USA
Tel +1 502 775-4241 · Fax +1 502 775-4249 · info.eckart.america.ky@altana.com · www.eckart.net

A member of **ALTANA**

ECKART
Effect Pigments

CAD RETEC® 2017

What's brewing
with Color?

Call For Papers

Deadline for Abstracts

March 1, 2017

Papers Due

June 1, 2017

CHAIRPERSON:

Bruce Mulholland, Celanese

bruce.mulholland@celanese.com

TECHNICAL PROGRAM:

Mike Willis, Sun Chemical

michael.willis@sunchemical.com

and

Ed Ford, Steer America

eford@steeramerica.com

One area we want to focus on this year is illumination and particularly the impact of LED lighting on our industry.



Milwaukee, WI

The Color & Appearance Division of SPE is putting together another great program for the CAD RETEC® 2017 to be held in Milwaukee, WI. The conference will be held September 17 – 19, 2017, at the Hilton Milwaukee City Center. The hotel is a great example of art deco construction built in 1927 with spectacular architecture. Originally we had planned to use space in both the hotel and nearby convention center. Recently we were able to work out our space requirements with the hotel so we will be located in only one venue

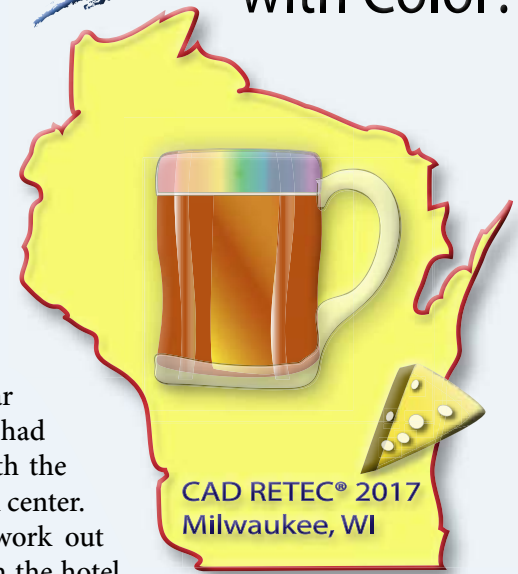
making it easier on attendees to keep everything all under one roof. This does not come without tradeoffs as our tabletop exhibits will be a little tighter and we will utilize three floors of the hotel for events instead of only one or two. Meals will be located on the lobby level, technical sessions on level 4, and exhibits/breaks on level 5. There are plenty of elevators, escalators and stairs to move from area to area.

The technical program will be held Monday and Tuesday, and is being put together by Michael Willis of Sun Chemical and Ed Ford from STEER America. Since we are in Milwaukee, our theme this year is “What's Brewing With Color?” We will have topics regarding the latest developments in the color industry from colorant suppliers, resin suppliers, equipment suppliers, processors and end-users. One area we want to focus on this year is illumination and particularly the impact of LED lighting on our industry. We will likely devote an entire afternoon session on this topic. If you are interested in presenting at the conference, please contact Michael or Ed as soon as possible.

On Sunday we will host a golf outing during the day, and will have our traditional opening reception from 8 – 11pm at the hotel in the evening including cocktails, appetizers and live music by “Color Eye Blind”.

We are continuing our offering of the New Technology Forum which allows exhibitors to showcase their companies and products or services. This will occur at its regular timeslot of late Monday afternoon immediately followed by the networking reception held in the tabletop area.

Please visit <http://www.specad.org/> for more information and on-line registration. Registration will open April 1st. I hope to see you in Milwaukee in September.



Bruce Mulholland
CAD RETEC® 2017 General Chair
bruce.mulholland@celanese.com
859-525-4756



CAD RETEC® 2017

September 17 – 19, 2017

Milwaukee, WI

The Premier International Conference for the Coloring of Plastics

The Color & Appearance Division of SPE presents:

“What’s brewing with Color?”

The CAD RETEC® conference is the technical and industry event for OEMs, processors, resin suppliers, colorant suppliers, equipment suppliers, testing and auxiliary equipment – anyone who works with color!

CONFERENCE HOTEL

Hilton Milwaukee
509 West Wisconsin Ave
Milwaukee, WI 53203
Tel: 414-271-7250
Ask for “SPE CAD” rate

EXHIBITOR INFORMATION

Contact: Brian West
Phone: 865-457-6700
E-mail: bwest@techmerpm.com

SPONSOR INFORMATION

Contact: Cheryl Treat
Phone: 419-217-0862
E-mail: cheryl.treat@ashulman.com

ADDITIONAL INFORMATION

Contact:
Bruce Mulholland
Phone: 859-525-4756
E-mail: bruce.mulholland@celanese.com

Conference Highlights

- ✓ Two full days of technical sessions
- ✓ 60+ exhibitors showcasing products/services
- ✓ Excellent networking opportunities

Advanced reservation deadline is:

August 18, 2017

For more information or to register online,
visit www.specad.org

Outstanding Achievement Award

This year's Terry Golding Outstanding Achievement Award goes to Mark Tyler.

The Terry Golding Outstanding Achievement Award was formerly known just as the Outstanding Achievement Award but was named after Terry because of his significant contributions in organizing the awards format as well being the best example of what it really means to be an outstanding achiever. On behalf of the CAD Board of Directors, we would like recognize Mark for his dedication, commitment, and always willing to help attitude embodies what this award is all about. He is responsible for and does a great job with the CAD Newsletter, has organized the RETEC® golf outing for the past 9 years now and he was this 2016 RETEC® Vice-Chair.



Councilor's Report



At the August, 2016 Council meeting, many Bylaws & Policies changes were approved which transform the governance of the Society from the current Executive Committee structure to an Executive Board model. Under the new EB model, specific Vice President positions have been created with detailed job descriptions and qualifications for each. All VP positions will be elected positions (unless mid-term vacancies occur). Two of the VPs, VP of Technology and VP Young Professionals will be elected by SPE members-at-large and not just by Council. The new governance model has VP positions directly linked to Society standing committees to provide better communication up and down the organization. The new Executive Board will provide direction and oversight for most Society governance matters allowing Council to focus on initiatives consistent with key Society objectives, including improving member value, expanding educational programs, etc. The new EB model will become effective at the start of the 2017 – 2018 Council year at ANTEC®.

In other action, SPE unlike most other societies has not increased its dues in over a decade. Member dues remain the largest source of revenue for SPE and provides much need support for all of its programs. Effective 2017, SPE member dues will increase to \$155. Dues that are renewed as part of a conference registration will increase from \$109 to \$135. This will impact conference fees for CAD RETEC® 2017.

Finally, as announced at the last Council meeting and by press release that you all should have seen, current SPE CEO Wim De Vos has decided to return to industry during 2017. SPE is beginning a search for qualified candidates for the CEO position. The search process is managed by the SPE Performance & Compensation Committee (PAC) comprised of Immediate Past President Dick Cameron, President Scott Owens, and President-elect Dr. Raed Alzubi. A professional search firm will assist the PAC with identification and vetting of prospective candidates. The SPE Executive Board will determine the final candidate selected.

Bruce Mulholland

Connect With SPE CAD Via Social Media

Join SPECAD's Group On Linked In to network with industry peers, participate in group discussions of industry and technical topics, find job opportunities, and get the latest division and conference announcements.

Group Name: SPE Color & Appearance Division

Group ID 152108

www.linkedin.com/groups?gid=152108





Society of Plastics Engineers Endowment Scholarship Program For the 2017 – 2018 School Year



COLOR & APPEARANCE

The Endowment Scholarship Program offered by the Color & Appearance Division of the Society of Plastics Engineers awards scholarships each year to students who have demonstrated or expressed an interest in the coloring of plastics industry. The students must be majoring in or taking courses that would be beneficial to a career in this industry. This would include, but is not limited to, plastics engineering, polymer science, coloring of plastics, chemistry, physics, chemical engineering, mechanical engineering, industrial design and industrial engineering. All applicants must be in good standing with their colleges. Financial need is considered for most scholarships.

Undergraduate and graduate scholarships range up to \$4,000 annually. Scholarships are awarded for one year only, but applicants may re-apply for each year they are enrolled in school.

Scholarship Eligibility

1. Applicants for these scholarships must be full-time undergraduate students in either a four-year college or a two-year technical program or enrolled in a graduate program.
2. All applicants must be graduates of public or private high schools.

Scholarship Criteria

1. Applicants must have a demonstrated or expressed interest in the coloring of plastics industry.
2. Applicants must be majoring in or taking courses that would be beneficial to a career in the coloring of plastics industry.
3. An applicant must be in good academic standing with his or her school.
4. Preference is given to student members of SPE and also to students who have a parent(s) as a member of the Color & Appearance Division of the SPE.
5. Financial need of an applicant will be considered for most scholarships.

Application Procedure

To be considered for a scholarship from the Color & Appearance Division Endowment Scholarship Program, applicants must complete an application available [on our website](#) and return it to the address specified on the application by **June 2, 2017**. All submitted applications must include:

1. A completed application form.
2. Three recommendation letters: two from a teacher or school official and one from an employer or non-relative.
3. A high school and/or college transcript for the last two years.
4. An essay by the student (500 words or less) telling why the applicant is applying for the scholarship, the applicant's qualifications, and the applicant's educational and career goals in the coloring of plastics industry.

Please feel free to contact [Ann Smeltzer](#) by email or by phone at 412-298-4373 with any questions.

QUALITY RESISTS.



Green, red, yellow, brown or black – our high-performance **Colortherm**[®] pigments have been particularly developed for the coloring of plastics. All pigments are easily dispersed and rapidly reach their final tinting strength. Their excellent properties in terms of heat stability, migration resistance, light-fastness and weather stability make them suited for almost any type of plastic. Thus, LANXESS quality ensures long lasting color stability combined with the highest technical standards.

www.bayferrox.com

X BAYFERROX[®]
Color for Life.

X COLORTHERM[®]
Color for Life.

QUALITY WORKS.

LANXESS
Energizing Chemistry

Technical Article

Fundamental Factors for Opacity and Tint Generated with Titanium Dioxide

John A. Crowther, Sandra P. Davis, Rajath Mudalamane, Philipp M. Niedenzu, A. H. Reid, Jr.
The Chemours Company

ABSTRACT

Titanium dioxide is a common pigment used in plastic applications to provide opacity. The opacity derived from a particular grade of titanium dioxide results from the optimization of several factors such as refractive index differentials, particle size distribution, levels of impurities, surface coatings and crystal phase. This paper describes the relationship of these factors with the pigment volume concentrations relevant to many plastic end uses and provides a general scale of which factor provides the most opacity impact. The paper highlights the areas of opportunity to tune opacity based on scattering for titanium dioxide particles due to particle size distribution and the expected boost in opacity. The matrices employed for the evaluation of optimization are tinted systems which demonstrate the relationship of pigment volume concentration with various particle size distributions. The results compare particle size distribution of various rutile products with elevation of the L^* values at constant TiO_2 loadings.

INTRODUCTION

Titanium dioxide pigments are widely used in plastics primarily to provide opacity which may also be described by terms as hiding power, tint strength or scattering. Titanium dioxide is considered an achromatic pigment since its ability to opacify is principally derived from the scattering phenomenon. The achromatic nature is in contrast to color pigments which may opacify via the absorption phenomenon, uniquely or in addition to scattering. The ability of titanium dioxide to selectively scatter certain wavelengths of light in a differential manner is a function of the pigment particle size diameter. The relationship of particle diameter and light scattering was first described by Walter Rayleigh (1) and further refined by Gustav Mie for spherical particles (2), Horvath (3) and Van de Hulst (4). Theoretically, the scattering efficiency, S , depends on only two parameters: particle size diameter and relative refractive index. The scattering efficiency will increase as the relative refractive index deviates from the value of 1. The fundamental factors of refractive index and particle size distribution dominate the opacity performance; the optimization of the two factors is the key for maximum opacity performance.

The main component of the relative refractive index value is the crystal structure of the titanium dioxide. The two commercially relevant crystal structures for titanium dioxide are rutile and anatase. The refractive index values for rutile and anatase for a wavelength of 590 nm range from 2.56 to 2.49 for anatase and 2.62 to 2.91 for rutile (5). Hence, the crystal structure adjustment can deliver an opacity difference near 10 to 15%.

However, light scattering efficiency is highly dependent on particle size distribution. While Mie theory is useful in setting the proper vector for opacity performance of commercial titanium dioxide materials, the theory is limited. The theory assumes spherical particles while commercial titanium dioxide products, rutile and anatase products, are crystals aggregated to various degrees. This aggregation reduces the scattering efficiency. Particle size distributions are routinely measured (6) and are useful in assessing the degree of aggregation. The level of aggregation is registered as an increase in the distribution width of particle size diameter, where d_{50} represents the mean particle size and the geometric standard deviation (GSD) characterizes the width of the distribution.

The demonstration of the opacity optimization with crystal structure and GSD can be noted in **Figure One**. A direct measurement of a titanium dioxide pigment scattering efficiency is to record the total transmitted light while exposing a dilute, lab-dispersed aqueous suspension containing the pigment. The transmittance at a particular wavelength is then converted into an "optical density" value which is defined by: $Optical\ density\ (OD) = -\log(\text{transmission}) / \text{concentration of } TiO_2$. **Figure One** confirms the impact of refractive index on the optical density, i.e., a 10% increase in relative refractive index difference translates into a 10% increase in optical density. Hence, rutile will always have 10% greater OD than anatase. Additionally, **Figure One** shows that within a given crystal structure, tuning the GSD to smaller values at a target particle size will increase the optical density; i.e., a 10% decrease in GSD within a crystal structure provides a 10% increase in optical density.

This preamble is intended to set the stage for reviewing the impact of particle size distribution in a tinted system using commercial rutile titanium dioxide materials. Herein is a demonstration of four commercial titanium dioxide pigments which differ in their GSD centered at a target diameter of nominally 0.30 microns and the impact in altering the color of a final mixture, primarily in the brightness scale (7). By blending the four pigments with carbon black in a PVC matrix, one can see the color progression as more rutile pigment is added.

Continued on the next page

EXPERIMENTAL

All samples were prepared utilizing a two roll mill heated to 300 degrees F. The roller speeds were set to 25 feet per minute (FPM) on the front roller and 35 FPM on the rear roller. Roll gap was set to be between 0.022 to 0.025 inches with a tolerance +/- 0.001 inch. All samples used 153 grams of a polyvinylchloride (PVC) stock formulation which has been pre-blended with carbon black. The PVC compound was slowly added to the gap of the revolving rolls. The compound plasticized in about 30 seconds and “banded” the front roller. After banding occurred, front roll speed was increased to 45 FPM.

Two minutes after banding, the titanium dioxide sample was added evenly across the roll gap. The procedure made 5 cuts of the titanium dioxide/PVC formulation band in 2-3 minutes. The white pigmented stock was cut from the front roller. Then the stock was folded and placed on the rollers to be banded again. 15 more cuts were made in the next 3 to 4 minutes (~15 seconds interval between cuts) and continued to roll for one minute. The final band was carefully removed from the roll by reducing the roll speed and placed on clean paper to cool, machine side up. The CIE values of the resulting sheet were measured on a Hunter Lab colorimeter.

The amount and the type of titanium dioxide added in the aforementioned procedure were varied based on the typical median particle diameter. The different titanium dioxide materials were used and dosage used to achieve the respective tristimulus values which are tabulated in **Table One**.

RESULTS AND DISCUSSION

The median particle size is the critical factor which distinguishes the four titanium dioxide materials reviewed. Pigment Type A median diameter is typically 0.33 microns with a geometric standard deviation (GSD) in the particle size distribution of 1.41. This pigment is tuned for the ideal median particle size and lowest GSD. Pigment Type B median diameter is typically 0.39 microns with GSD of 1.56 and serves as the type with non-optimal median diameter and a broad GSD. Type C is typically 0.35 microns with 1.44 GSD and serves as an example of “compromise of low GSD with non-optimal median”. Lastly, Type D is the largest particle with a diameter near 0.41 microns and the broadest GSD of 1.58. The tint experiment is designed to highlight the level of strength increase which can be achieved with relative adjustment in particle size as measured with laser scattering techniques (6). The intent is to note “how much more” tint efficiency can be achieved with decreasing the median particle diameter and GSD at a target particle diameter.

The impact of different rutile titanium dioxide materials on the final part color can be charted by noting the relationship between the CIE L^* , a^* and b^* color axis (7). The CIE $L^*a^*b^*$ evaluation describes a color space using three coordinates. The L^* values describes the diffuse white (i.e., $L^* = 0$ is black, $L^* = 100$ pure white), a^* axis represents the red to green scale (a^* negative indicates green) and b^* is the position on the blue and yellow scale (b^* negative indicates blue). The main impact of particle size adjustment is noted in the brightness, L^* (see Figure 2). Sample “a” performs with the highest L^* value while sample “d” demonstrated the lowest. The brightness titration indicates that Pigment A has the median diameter and GSD values for maximum scatter amongst the sample set since it demonstrated the highest brightness. Pigment C has the same GSD by a slightly larger particle diameter. Pigment B had a slightly larger median compared to A and C with a broader GSD. Of course, sample D was the control material which had the largest median and broadest GSD.

A secondary way of reviewing the impact of diameter and GSD is to compare Delta E values as the median particle diameter and GSD decrease from Pigment D. **Figure 3** highlights the differential as a “delta E*” when using Pigment D as the reference (see **Table 2**). As the median particle decreases the Delta E starts to increase. This increase is noted when looking the Delta E values of Pigment B which has similar GSD to the Pigment D but smaller diameter.

A similar conclusion can be draw by comparing the Delta E for Pigment A and C. In this comparison, the GSD values are similar but the particle diameters are different. Unfortunately, amongst the commercial pigments reviewed, de-convoluting the impact of GSD from particle diameter in a conclusive manner remains elusive. The hypothesis is that the dramatic delta E noticed for Pigment A is a combination of the ideal median diameter and small GSD value. To firmly establish this hypothesis, a commercial sample of ideal diameter but non-ideal GSD needs to be identified and compared with Pigment D.

Continued on the next page

CONCLUSIONS

The ability of commercial titanium dioxide materials to tint carbon black in the PVC formulation is primarily determined by combination of the particle size distribution as defined by the median particle size diameter and the GSD. The cursory review of four pigment types reviewed demonstrate the relationship of diameter. Pigment A demonstrated the highest level of tint (highest brightness) of the samples reviewed, especially at the low rutile pigment loadings. Pigment D demonstrated the lowest tint capabilities at all pigment loadings.

The tint evaluation is congruent with the relationship of PSD and opacity evaluation when defined as “optical density”, i.e., a target particle diameter yields more efficient tinting. The influence of GSD on tint performance seems directional at this point, i.e. lower GSD should increase tint performance

REFERENCES

1. P. Lilienfeld, “A Blue Sky History”, Optics and Photonics News, 15 (6), pp. 32–39, (2004)
2. M. Gustav; “Beiträge zur Optik trüber Medien, speziell kolloidaler Metallösungen”, Annalen der Physik, 330 (3), pp. 377–445 (1908)
3. H. Horvath, “Gustav Mie and the scattering and absorption of light by particles: Historic developments and basics”, J. Quantitative Spectroscopy & Radiative Transfer, 110, pp. 787–799, (2009)
4. H. C. Van de Hulst, “Light Scattering by Small Particles”, Dover Publications, New York, pp. 470, (1981)
5. J. Rams, A. Tejada, and J. M. Cabreraa, J. Appl. Phys. 82 (3), pp. 994-997 (1997)
6. N. Stanley-Wood and R. W. Lines, “Particle Size Analysis”, Royal Soc. Chem., Cambridge, U.K., (1992)
7. R. Berns, “Billmeyer and Saltzman’s Principles of Color Technology”, 3rd Ed., J. Wiley and Sons, (2000)

Table 1: Tri-stimulus values of PVC carbon black sheets

sample	grams pigment	L*	a*	b*	X	Y	Z	DELTA vs. sample d
a	1	51.15	-0.72	-2.06	18.26	19.4	21.95	6.11
a	2	60.36	-0.74	-1.67	26.86	28.53	31.79	5.24
a	4	68.64	-0.69	-1.26	36.62	38.84	42.77	4.10
a	5	70.9	-0.67	-1.15	39.64	42.04	46.16	3.43
b	1	50.49	-0.62	-1.43	17.74	18.83	20.97	2.49
b	2	59.67	-0.62	-1.07	26.17	27.76	30.53	2.14
b	4	68.06	-0.6	-0.78	35.9	38.06	41.5	1.83
b	5	71.1	-0.6	-0.67	39.94	42.33	46.04	2.36
c	1	50.57	-0.67	-1.72	17.79	18.9	21.2	3.52
c	2	59.97	-0.69	-1.34	26.46	28.09	31.08	3.32
c	4	68.41	-0.67	-0.99	36.33	38.53	42.2	2.82
c	5	70.76	-0.65	-0.9	39.46	41.84	45.71	2.46
d	1	49.71	-0.44	-0.07	17.16	18.18	19.54	0.00
d	2	59.29	-0.43	0.33	25.82	27.34	29.11	0.00
d	4	67.69	-0.44	0.51	35.48	37.55	39.87	0.00
d	5	70.16	-0.42	0.53	38.72	40.98	43.5	0.00

Table 2: the median particle diameter and geometric standard deviation (GSD)

TiO2	median diameter in microns	GSD	DELTA E at 1 gram	DELTA E at 2 gram	DELTA E at 4 gram	DELTA E at 5 gram
A	0.33	1.41	6.1121	5.241	4.0979	3.4325
B	0.39	1.56	2.4904	2.1405	1.8266	2.356
C	0.35	1.44	3.515	3.3189	2.8213	2.4578
D	0.41	1.58	0	0	0	0

Figure 1: Rutile and Anatase materials of various GSD and their optical density values

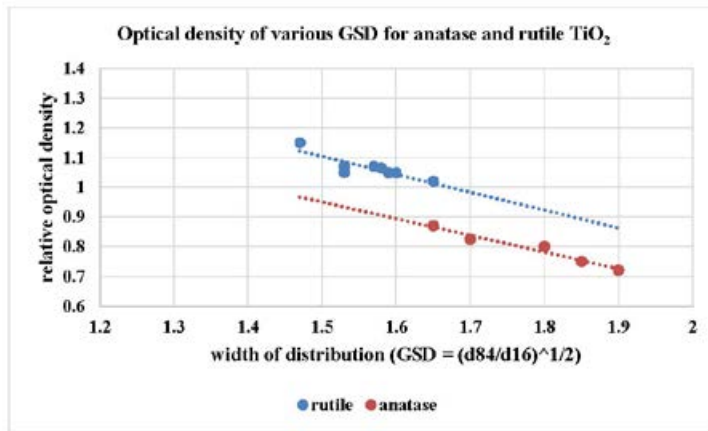


Figure 2: Brightness values for samples as a function of TiO₂ amount in PVC formulation

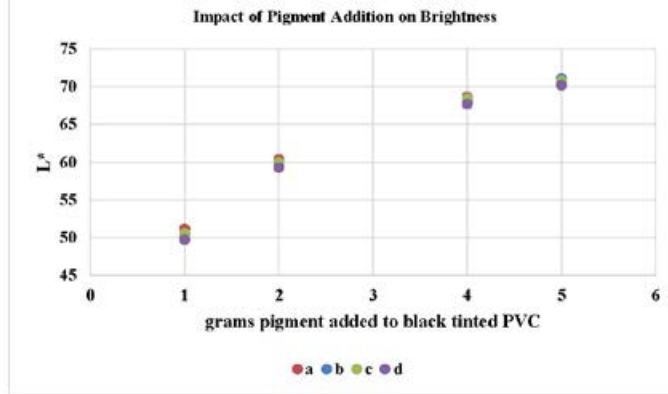
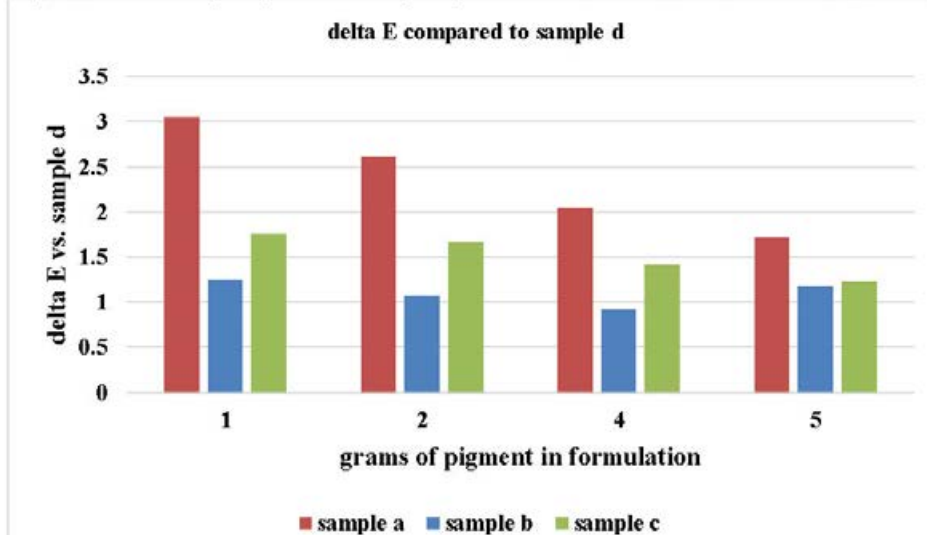


Figure 3: delta E (compared to sample d) as a function of TiO₂ amount in PVC formulation



CAD OFFICERS

Chairman:
Brenda Mullins, 313-923-7113
BASF Colors & Effects
brenda.mullins@xxxbasf.com

Chair-Elect:
Cheryl Treat, 419-217-0862
A. Schulman Inc.
Cheryl_treat@xxxus.aschulman.com

Finance Chair:
Jim Rediske, 914-785-2203
BASF Colors & Effects LLC
james.rediske@xxxbasf.com

Secretary:
Doreen Becker, 914-769-1679
Ampacet Corporation
doreen.becker@xxxampacet.com

Immediate Past Chairman:
Jeff Drusda, 570-668-8321,
Silberline Manufacturing Co., Inc.
drusdaj@xxxsilberline.com

Councilor:
Bruce Mulholland, 859-525-4756
Celanese
bruce.mulholland@xxxcelanese.com

Treasurer:
Bruce Mulholland, 859-525-4756
Celanese
bruce.mulholland@xxxcelanese.com



Note: remove xxx after ampersand in email addresses before emailing – added here to prevent bots from capturing email.

CAD DIRECTORS

DIRECTORS until 2017

Breeze Briggs, 248-304-5303
BASF Colors & Effects LLC
breeze.briggs@xxxbasf.com

Sharon Ehr, 616-494-7577
Uniform Color
sehr@xxxuniformcolor.com

Steve Esker, 614-679-4677
Paramount Colors, Inc.
steveesker@xxxhotmail.com

Mark Freshwater, 201 665 0091
Lansco Colors
mark@xxxpigments.com

Todd McHenry, 412-809-4732
LanXess
todd.mchenry@xxxlanxess.com

Jamie Przybylski
jkjkski@xxxmyway.com

Austin Reid, 228-255-2362
Chemours
austin.h.reid-jr@xxxchemours.com

Mark Tyler, 859-372-3221
Celanese
mark.tyler@xxxcelanese.com

Fang Wang, 248 304-5233
BASF
fang.wang@xxxbasf.com

DIRECTORS until 2018

Earl Balthazar, 817-719-0224
DataColor
ebalthazar@xxxdatacolor.com

Alan Bodi, 419-515-0578
abodi@xxxex.net

Bruce Clatworthy, 416-791-4254
Dominion Colour Corporation
bclatworthy@xxxdominioncolour.com

Sandra Davis, 302-683-8025
Chemours
sandra.p.davis@xxxchemours.com

Ed Ford, 302-745-3319
Steer America
eford@xxxsteeramerica.com

Jack Ladson, 267-981-7112
Color Science Consultancy
jack@xxxColorScienceConsultancy.com

Alex Prosapio, 845-641-8566
Cappelle Inc.
a.prosapio@xxxappelle.be

Michael Willis, 513-681-5950
Sun Chemical
michael.willis@xxxsunchemical.com

DIRECTORS until 2019

Scott Aumann, 912-210-0175
EMD Chemicals
scott.aumann@xxxemdgroup.com,

Chuck DePew, 765-914-3363
Holland Colours Americas, Inc.
cdepew@xxxhollandcolours.com

Jim Figaniak, 215 736-1126
Infinity LTL
jim.figaniak@xxxltlcolor.com

Scott Heitzman, 513-681-5950
Sun Chemical Corporation
scott.heitzman@xxxsunchemical.com

Nathan Karszes, 770-527-2409
Ferro
nathan.karszes@xxxferro.com

Betty Puckerin, 812-466-9828
Ampacet Corporation
Betty.puckerin@xxxampacet.com

Mark Ryan, 513-874-0714
Shepherd Color
mryan@xxxshepherdcolor.com

Ann Smeltzer, 412-298-4373
Clariant Plastics & Coatings
ann.smeltzer@xxxclariant.com

Brian West, 865-425-2113
Techmer PM LLC
bwest@xxxtechmerpm.com

