Trey: Hello everyone, and thank you all for joining us. Today's webinar, "How to Reduce Small Appliance Noise Without Reducing Performance," is brought to you by Eastman. Your presenters today are Dr. Steven Givens [SP] and Alex Dudal [SP]. Dr. Givens is a senior polymer application scientist responsible for new application development, market-focused research product development, and product performance for Eastman Tritan Copolyester.

Joining Dr. Givens is Alex Dudal. Alex Dudal is responsible for market development activities related to Eastman Copolyesters and non-food contact applications for consumer durable goods including 3D printing, major appliances and electronics markets.

My name is Trey McDonald with you all and I'll be moderating today's event. You can send us questions by typing them in the question box that's located on your screen, and our panelists will answer them at the end of the presentation.

We are recording today's event and we'll send you a link by email when the slides and video have been posted to the Prospector Knowledge Center. With that election, the presentation are with Alex. Alex?

Alex: Thank you, Trey. Before we get started, I want to say a couple of words about Eastman Chemical. We are a global specialty chemical company that produces a broad range of advance [SP] materials, additives and functional products, specialty chemicals and fibers. We are based and Kingsport, Tennessee but we employ about 15,000 people worldwide at our 50 manufacturing sites and serve customers in about 100 different countries.

We're also dedicated to environmental stewardship and social responsibility, which is why we have been named a Responsible Care company for more than 25 years. And just this year, we have been awarded ENERGY STAR Partner of the Year. We've also been named one of the World's Most Ethical Companies, and we've been voted number 11 by our own employees, number 11, Best Place to Work in the United States through the Glassdoor website.

So to give you a quick overview of what we're going to cover today, we will talk a little bit about what consumers want specifically in the appliances, small and large appliances markets, and then we'll focus a lot on really understanding how Eastman Tritan Copolyester can help enable improvement in acoustic performance in a variety of applications, as well as we'll briefly cover some of the other advantages Tritan might have for those areas including aesthetics, toughness and durability.

And then we'll wrap up with the question and answer session where we'll address some of your potential questions. So what do consumers want for the small appliance and just appliance market in general?

Well, functionality will always be important. They would want their blender to blend, and their vacuum cleaner to clean, and dishwasher to wash dishes. But brand owners in recent years have done a really good job designing appliances that do their work really, really well, that provide variety of design options and colors, and provide variety of new additional features from variety of cycles to connected devices and things like that.

So in this mature market, it becomes more and more difficult to compete, and more and more difficult to come up with products that are differentiated and innovative.

So a lot of other properties and a lot of other benefits become a lot more important outside of just functionality. One of those, clearly, sound. In fact, I would say this is probably one of the next big areas where brand owners can differentiate their products.

There's large amount of research available out there that shows that consumers are actually willing to pay premium prices for quieter appliances and that can really impact the way consumers enjoy and appreciate their appliances. So just a few examples here: there's Electrolux report of noise that was published three years ago, that actually showed that about half of the consumers are willing to pay 10% price premium for an appliance that’s noticeably quieter but has the same level of performance.

We'll talk about the second point in more detail in a second, but really for one…every one decibel that the noise is creating for a dishwasher goes down, the price goes up by about \$71, which is a substantial margin improvement. And then there's a lot of other surveys that were conducted that really showed things like 39% of the people will actually avoid using an appliance in certain times during the day because of the noise they produce. And 62% of the people actually felt that noise from appliances adversely affected the enjoyment of their home life to some extent.

So if you're actually want your consumers, your customers to use your products more often and enjoy them, certainly improving the sound performance of those appliances is a big area of improvement. That was in general, but talking about couple category and specifically, we can talk a little bit about high performance blenders, which is one product that certainly generates a large amount of noise for a very short period of time.

So what we've done is we've looked at reviews for 12 different blenders on Amazon.com, and here's some criteria that we used. They all had a power rating of at least a thousand watts. They were all priced at over \$100, and to be a high-end product, and we chose a variety of different brands, both more popular, well-known brands as well as maybe less known brands.

And the other thing is each blender product had to have at least 50 reviews so we had a good sample size. So what we did then is really just search for word “loud” within all those reviews to understand how often and what in what context it was mentioned. That gives you a pretty good idea of how often consumers really think and equate the noise level of their product when they actually rank and review your product.

So before we go into the data, there's a couple more colorful good example that I think sometimes speak better than charts and, you know, graphs. So a few examples here. Obviously, one of the main things we learned is that consumers can be really creative when they review products online. For example, comparing it to “an F16 taking off in the living room,” while at the same time something to know what its rank in a product, five stars.

The second review there is really interesting, because it actually…they actually said that the only reason they ranked a product four stars and five was noise. So certainly, that's one of the biggest barriers sometimes to really getting full customer satisfaction. That's a good example of that.

And the third review is a good example because it underscores the idea that customers actually almost expect third products to be loud. So a blender is loud, but which blender isn't? And, again, if your goal as a brand owner, as a developer of new products, to actually delight customers, to surprise them, this is a good way to do that. To come up with a product that has unexpectedly improved sound performance.

And then a few other colorful examples, comparing it to “a jar of angry hornets,” or “worrying about going deaf,” or comparing it to “a tornado that might tear your house down.” Obviously, all are very colorful, interesting examples.

So now looking a little bit of the data, this will show you actually which blender models exactly we've looked at. They all had very good ratings as you can tell. Most of them are over four stars on average. So these are well-reviewed products. And as you can see across all categories, across all reviews, about 8% of reviewers actually talked about loudness of the product in some context.

So you can see, almost one tenths of customers who review products think about, at least blenders, think about the sound level that those products produce. The other interesting point here to notice is that in the four and three-star categories, especially the four-star categories, those are the areas where consumers mentioned the product noise level the most. So as you can see, it's not quite as important in the five-star and one-star range, and this could mean that product...the reviewers, they tend to maybe think more about it and put more thought into their reviews, and potentially be more critical are the ones that tend to pay attention a lot more to that characteristic.

So now let's talk about a different product in the, basically in the opposite end of the spectrum, when it comes to sound performance. So in the blenders, you have products that makes a large amount of noise in a very short period of time, and dishwasher's a product they're on for a very long time and makes a relatively low amount of noise by comparison.

So what we were able to do there, because most of the dishwasher products are fairly similar, there's a lot less variability in that than in blenders, they can be compared a lot easier. So what we've done is we looked at 172 different dishwasher models that were available at a large big box home improvement store in US. And we isolated about 12 to 15 different variables across all these product categories.

Those included things like what color it was, where was the control panel, was it hidden or exposed, the number of wash cycle that had, the top material, whether it was metal or plastic. The brand was one of those and the sound rating that provided for that product was also another one.

So doing the regression analysis, what we were able to find actually is that sound performance, out of all of those variables, really had the biggest influence on the price of the dishwasher compared to all the other ones. That, in fact, was also statically significant, even bigger influence than a brand and other things. And basically the most interesting one is that, on average, every time the sound level of a dishwasher went down by one decibel, the price went up by about \$71.

So there's certainly an opportunity to create products with higher margins and higher end that consumers are going to pay more for by improving sound performance. This is just a quick example that shows you what brands we've looked at and how the data looked like, just a couple things to point out here.

AGA and Dacor brands were actually excluded because most of the other category, most of the other brands had a full range of products that went from lower priced to high-end products. For those two brands, they only were premium categories.

So actually that actually skewed data somewhat, and including those means that every time the sound reduces to one decibel, price goes up actually by \$78. So in the same time, as you can notice, it seems that reducing noise in even a lower end of the range, so in an area where it's already fairly quiet, creates even more value, so that additional increment of noise reduction actually becomes more and more important the quieter the products get.

And finally, you know, we can talk about reviews and pricing and things like that, but really in the blender level at least, it's pretty clear that there's certain opportunity for improvement when the products that are created currently fall somewhere, on the noise scale, between a lawnmower in an area that OSHA considers potential for causing hearing damage at a prolonged sound level.

So now that we know that this is certainly an area that can help our customers, help brand-owners differentiate their products, help create products that consumers value, what can you do about it? And this is where I'm going to handover the presentation to Dr. Steve Givens to talk, in detail, about how Tritan can enable you to improve those aspects of your product.

Dr. Givens: Thanks Alex. Thanks everybody for joining us on the webinar today. I'd like to switch gears a little bit and talk about some data that we've developed, looking at fundamental aspects of the way Tritan dampen sounds that lead us to believe that it may be a pretty good cost-effective solution in reducing noise in small appliances and other things like boom [SP]in microphones. It'll reduce feedback from sort of seismic interference.

It can also cut down on the interference from, say, an over-the-head earphones, the kind of noise that's impeding on that shell. So reducing noise in small appliance with the mechanical motors is really the focus of this research.

And an interesting phenomenon happens when you mount an electric motor to a hard surface. You essentially make that outer shell a resonator, like the body of a guitar. And so what happens is there's vibrations that's provided by the motor that drives the appliance and gives it the function that you need. This vibration reverberates and radiates from the surface an audible noise.

There are few ways to address this. You can reduce the vibration of the source. This usually entails having a less powerful motor which often reduces the performance of your device. You can isolate the mechanical vibration just as sometimes done with rubber bushings. This is a good idea until you actually compress the rubber when you install the motor. Once you compress the rubber, it doesn't dampen nearly as well.

And then the third choice is to improve the damping or smocks of the materials that you use in the housing and the construction of the blender for any small appliance really.

So reducing noise in small appliance, we think that choosing materials with good sound damping properties is a simple and very cost-effective way to achieve substantial and noticeable reduction in the noise of a small appliance. And it's not actually only the noise level. It's also the frequency of that noise. We'll get into this data in just a second.

So there's a range in human hearing somewhere between 2,500 and 5,000 hertz that's extremely irritating. That's the sound of males on a chalkboard, and babies crying, and dogs howling. And a lot of the noise is generated by a blender made out of engineered resin that has high modulus is in that irritating range.

So to look at this, we decided to test materials to compare their damping properties with a number specific test. And then we'll look at these results that pretty strongly conclude that Eastman Tritan Copolyester compared to a number of competing materials has a significant advantages in vibrational damping.

So the test that we used to determine this advantage is what's called center-point impedance measurements. This is sort of a crude diagram of how the test is done. So everything here is done in an anechoic chamber so there's no interference from echoes or external noise. And [inaudible 00:15:13] in the upper left-hand corner, the picture in the upper left-hand corner of the slide.

If you look at the upper right-hand corner, this is actually the sort of a test band [SP]. So that round cylindrical object in the bottom is a frequency generator or a shaker, some people might call it, that has a accelerometer built into the head.

So you'll notice there's a panel material that's mounted there. That's the best the material to be tested. So basically you mount this to this frequency generator. You apply that frequency to the material and then with the accelerometer, you look at the materials' response so that frequency.

And in the picture in the bottom shows the software and the sort of frequency splitters that are required to do all this in real-time. And what you'll find out is based on the center-point impedance measurements, you can come to ultimately what's called the damping response factor.

And so we use this testing to compare Eastman Tritan with a number of other materials with the center-point impedance test. And plotted on a graph, which you'll see in just a second, is the materials that exhibit lower frequency response. That's to say that the peaks are smaller on the graph and they more quickly return to a base line, have a better damping performance.

And based on this data, which we have generated for probably a couple dozen materials now, you can calculate this loss factor. And materials that have a higher loss factor exhibit better sound damping properties. So, ultimately, we take some very complex physics, and we reduce it down to a number that you can use to compare a lot of things with. And, again, the higher the number, the better the damping response.

And so we found is that Tritan exhibits a better sound damping properties against all the materials that we evaluated so far. And it has an especially large advantage in damping versus things like polycarbonate glass, PCABF, some of the more common materials used in this space.

So this is an example of that center-point impedance test. This is the data that results from this test. This is kind of blown up to illustrate each individual peak and how the height of the peak and how quickly those peaks attenuate back to sort of a baseline, and how important they are to ejaculate in this damping response factor.

This is blown up between five and a thousand hertz. We actually run the test to cross the entire spectrum of human hearing from about 20 hertz to 20,000 hertz.

And what this does is it illustrates how the material actually propagates this vibration through the material. And it can either increase or dissipate the energy, the frequency of that vibration and also the speed of the vibration. This is due to the viscoelastic nature of the material. And so it's a viscoelastic response to actually the energy being propagated through the material.

So what you'll see here in this slide where we compare Tritan with the blue line, Spectar, which is another Eastman material in the red line, and Sabic LEXAN in the green line, is that Tritan not only vibrates at a lower frequency, it also…the peaks have less amplitude and they return to the baseline more quickly. And we'll illustrate that a little better in a bigger frequency range in the next slide. And what this is is actually, on the X axis, is that is force over velocity. So it's newtons per meter, per second.

So that's actually how the way it moves through the material, how fast it moves and how much force it moves with over the frequency at which the material vibrates. And so if we go to the next slide and we look at a another consideration, say, where Tritan again is in the blue line, AVS is in the red line and glass is in the green line, this is the same type of testing over a wider frequency range, from 5 to 5,000 hertz. Again, up to 5,000 hertz because that's the top of that really irritating range for human hearing.

And what we heard, Alex was showing us some of the reviews that we found online. And one reviewer said, "You know, I've got this really expensive \$700 blender, and no matter where I run it in my house, it wakes my baby up." And this is an example of how that can actually happen.

So you'll notice that glass, which people think is great at really blocking sound, it's good at blocking transmitted sound, but it actually vibrates quiet strongly all the way up to 5,000 hertz, so all the way across that irritating range. And this is because glass is not viscoelastic in nature. It has no viscoelastic response. So it doesn't have the ability like in this case, even ABS has a better ability to slow the force and the velocity of that wave down than glass does.

And you'll notice again that Tritan vibrates at a lower frequency here. The peak caps [SP] are lower and that, more quickly, Tritan reaches that baseline. So somewhere around 2,000 hertz to 2,500 hertz is kind of a last vibration, the last peak you'll see for Tritan. Whereas ABF here has a distinct…peaks out to around 4,500 hertz.

And so this is why a blender made out of these other materials is not only louder but it makes the sound that may irritate you more, essentially, a higher, thinner [SP] pitched sound. And so basically we take this data. We use this data to compare Tritan and other copolyesters with other engineered resins.

In the next slide is an example of the damping loss factor summary of polycarbonate versus copolyester, so Tritan in specific. And you'll notice here that each one of these vibrations, this is the first eight mode, so basically the first eight vibrations that you see in the previous two graphs. They represent most of the response or they allow you to predict most of the response of the material out to very far vibrations.

And so you’ll notice that in every frequency here, Tritan is actually vibrating at a lower frequency. So the first mode is at 23. For Tritan, it’s at 26.5 for polycarbonate, all the way up to the 8th mode, which is 805.3 for Tritan and 1,075 for polycarbonate. And so this illustrates the higher PH of that sound, the teenier, slightly more irritating part of that sound. And then the damping loss factor, so you'll notice for Tritan it's 0.044 whereas for polycarbonate, it’s 0.007.

So basically Tritan has six times the loss factor, or over six times the loss factor of polycarbonate. And this higher loss factor indicates a better ability of the material to dampen sound created by mechanical vibrations. And in practical applications, for noises generated by the housing of one of these motorized devices or vibrations, say from a spoken voice, is transmitted down the boom to a boom microphone, this ability to dampen that vibration makes things like a polycarbonate are perceived to be over three times louder.

And so to understand that a little bit more, we did a very simple experiment. So we wanted to look… We wanted an example of the mechanical damping of sound damping. And so what we came up with was a rather simple example of a shaker, like of a big baby rattle. And what we did was took a beer mug. We injection molded these beer mugs out of a bunch of different materials, probably like 12 materials now.

We kept the bottom off of one beer mug, and solved [SP] and welded it to the top of the beer mug. And we put some ball bearings in it, and that allows you to generate noise from this housing, so from the beer mug, by mechanically vibrating it with the impact of the ball bearings inside the mud, in the closed mug. And so no matter how hard or soft you try to shake these things, there's a noticeable difference in sound quality.

So it's the irritation level and overall sound. And what you can see here is that… So the Tritan mug shaken very vigorously, it's about as vigorously as we could shake it, 10 or so times in an average, came out with a decibel level of around 106. Where the acrylic mug came out at 122.7. The methacrylate styrene mug came at 124.9, polycarbonate, 123.9, and SAN, 124.6.

And so it's important here to remember that decibel has a logarithmic relationship. So a 10dB increase in sound is perceived by the human ear as being twice as loud. And so when you look at that, that 16-decibel difference between Tritan and Acrylic, roughly 16 decibel, translates it into being about 312% louder. And then e-mass is 363, PC, 339, and then SAN, 356.

So these Tritan shaker cups, they produced the lowest noise. They produced the noise that's a little more friendly in the frequency range, so it wasn't quiet as irritating. And these other materials, you know they're over three times louder than Tritan. And so that's a good example of just pure damping. You can eliminate all the noise generated by the motor itself. You can eliminate all the noise generated by the blades. And it's just the ability of the material to dampen that mechanical vibration.

And so to sort of summarize what we just talked about, dampen loss factor, before we move on to some more specific testing that we've done in blenders and sales is, again, when motorized equipment such as an electric motor is mounted inside a solid structure like the base of a blender or even a vacuum cleaner, energy can be transferred to the surface of that equipment. And then this vibration could radiate from the structure as an audible noise. Damping reduces the amplitude of these resonant of vibrations. A higher damping loss factor indicates better damping and the Tritan damping loss factor is 0.044. And Tritan's damping loss factor is significantly better than polycarbonate glass, SAN, Acrylic PCABS, pretty much everything we've tested so far.

So once we sort of developed this base data, we wanted to take it and apply it to real world applications. And so we were most interested, and the focus of this presentation, is around high powered blenders. So what we did was we went out and bought 16 blenders on the marketplace.

So they're complete blenders from their manufacturers. And what we really wanted was that source of vibration. And the source of vibration that causes pretty much all the sound in the blender is the motor. And so if it's the base vibrating, or if it's the impact of the food to the jar, all that energy is still coming from the motor. And so what we did was we bought these motors and we bought these blenders.

We took the motors out of them and whatever electronics that was required to make them run. So that's the picture, the lower left hand corner of this slide. And we built boxes out of different materials to mimic the housings of these blenders. So we didn't have any way, we didn't have any molds to actually make a blender cover or blender housing. So we built boxes.

And in order to do that, each motor is unique. And so you can see in the bottom right hand corner here, there's a picture of several of these motors. Each one is made differently. Each one is mounted differently. So when we took them out with the electronics, we had to build them out of each material we want to test for each blender. So and then we performed sound testing.

And so the way we did that is we mounted these motors in boxes and here we're gonna talk specifically about a box, a six-sided of box made out of Tritan, one made out of polycarbonate, one made out of PVC. And so you can see each material is mounted on a mount that's unique to that motor, and is mounted directly to the box. The only thing that... The only other thing we kept is the electronics, so like an override circuit to make the blender motor actually work.

And so this allowed us to engage that motor at full speed, 100% output which allowed us to generate those vibrations like you would in a blender that would cause the box to vibrate, create that audible sound. And so we did this for a series of materials. Here, again, we're gonna talk about Tritan, PC and PVC. We very carefully took measurements from the box.

So in this consideration, say, we're gonna talk about blender motors. They range in power. And we took three readings each from the top, the front top and the back. We averaged those out. We were very careful to keep the decibel meter at the same distance from the box, which in this case, turned out to be about four and a quarter inches.

We did all these measurements in the DBA weighting system, which is the most common measurement scale in DBA, and it’s also the one that's designed around conversational use. So what you'll see is that, from this, from the six different models, where model 1 was about a 900-watt power motor up to model 4, which was about an 1,800-watt motor, you'll notice that the noise emanating from this box, from the vibration caused by that motor, Tritan is the quietest and in some places, it’s significantly quieter.

So in model 1, Tritan is about 14 decibels quieter than polycarbonate. In, you know, model 2, you see a bigger gap between PVC. But, again because of the viscoelastic nature of Tritan, kind of that unique backbone that's proprietary to Eastman, Tritan is very, very good at damping vibrational energy.

So once we've developed that, and we thought the fundamental tests are falling in line with what we're seeing in the real world, with what we're seeing with our shaker cups, we had customers that ask us a question. "Well. Okay. So you can give me 6 or 8 or 10 decibel reduction by switching from, say, PCABS to Tritan in my base. What if I need more?"

And so what we wanted to do was develop a relationship to look at how we could reduce noise even more. And so what we did is we, again, we built a box. This again is a six-sided box. This one, we insulated with acoustic foam to make it a semi-anechoic chamber. And we put blender bases in that were not disassembled, so fully assembled blender basis.

We took the same type of rating with the same type of decibel meter, also, again, in DBA. And this time we looked at, in this consideration, say we've got about 9 blenders ranging from about 550 or 600 watts from brand 1 up to or 2,100 watts or 2,200 watts for brand 9.

And again you'll notice that if you increase Tritans' thickness by two X, by... You'll see about a six dB reduction in noise. So if you'll look at that first column of numbers, you know, the first column is at a quarter or an eighth of an inch in thickness. And then if you go to a quarter of an inch in thickness, you get a reduction of about six dBs across that line for brand one. That holds true through all nine brands here through all different watt ratings of the motors. And then if you increase Tritans' thickness by 50%, you see about a 3 or 3.2 decibel reduction. That also holds true across all these nine brands.

And so finally, we were able to find a real world comparison. So this is two blenders made by the same company with exactly the same motors, exactly the same blades, exactly the same everything. The difference is the blender on the left, the jar is made out of polycarbonate at about a three millimeters thickness, and the blender on the right, the jar is made out of Tritan. It’s also, again, about three millimeters thickness.

And what you'll notice from the decibel meter is running at full power blending popcorn, which is our analog for a really hard food stuff, is that the Tritan blender is four decibels quieter. I should say the blender jar is four decibels quieter than the polycarbonate blender jar.

And so that's purely from just material change, from a stiffer material that does a good job damping to a material that does a better job damping. And so four decibels, again, that's about a 32% reduction in the loudness of this blender. So it's extremely noticeable.

So I think we've done a pretty decent job of presenting some data that shows that vibrational damping is an advantage in the Tritan Copolyester. There are other things that make Tritan compelling for this market space also, and I'd like to segue a little bit and talk about some of those. So home devices, especially kitchen devices, they spend a lot of time in your counter. People spend a lot of money in their kitchens. They spend a lot of time enjoying cooking and eating in their kitchens.

So aesthetics of all these products becomes extremely important. And one thing you'll see, with Tritan Copolyesters has excellent aesthetics [inaudible 00:35:31] our little chameleon [SP] friend here who’s standing on a bunch of Tritan-colored chips. And you'll notice how vivid and glossy these colors are. And you can see the color tablets in the bottom left-hand corner. It's pretty striking that you can actually see the reflection of the white tablet in the face of the black tablet.

Most of our customers refer to the look of these opaque Tritan housings as a “wet paint” look so it allows you to make a really vivid, beautiful, glossy color that’s created straight out of the mold. So a lot less expensive secondary operation so you can skip painting steps and some coding steps and maybe even some in-mold decoration or in-mold labeling steps.

So Tritan really allows you to make appliances that look as good as they sound. The copolyester, Tritan Copolyester allows you to create devices that have very vibrant colors and outstanding gloss that that beauty will not fade. It won't crack or haze to an exposure to chemicals and common foodstuffs, even household cleaners. We also have excellent design in tech service to help you achieve these aesthetics without having the paint or use secondary operations. And then Tritan also performs very well in a variety of secondary operations, so you do... You don't [inaudible 00:37:07] how we lose that possibility if you wanna do things like in-mold decoration or hard coating surface texturing or painting. Those options are still there with Tritan.

And so toughness and durability, it's an interesting aspect. Copolyester is, in general and Tritan especially, are known for being extremely tough and durable. And so toughness and durability, they're used interchangeably but they're really not the same thing. So, you k now, a tough material may not be durable when it comes to exposure to certain chemicals or exposure to certain foods. It may also, the mechanical properties may not be really on par with everything else. And so here's just the simple comparison between a couple of different rates of PCABS which are common in this market, especially in housings and in Tritan.

And so you'll see that break stress. Everybody's kind of on the same level but break with elongation really stands out for Tritan 216. Modules [SP] is a little less for Tritan but that's one of the things that allows it to be so durable. Notched [inaudible 00:38:18] so if you wanna think purely about impact, [inaudible 00:38:21] outstanding. So is multi-axial impact. A really good heat deflection temperatures for Tritan are also very respectable for this type of market. So Tritan is extremely hydrolytically stable that's very, very well into dishwasher.

And so I think this really illustrates the point that durability goes beyond just mechanical properties. And mechanical properties don't often tell you the whole story. I mean, they're very good on a data sheet used to compare to materials, but material performance can be impacted by a lot of things, and especially the exposure to chemicals, stresses, whether either applied stresses or inherent stresses. Cold temperature performance varies widely and so does hydrolytic stability.

So one thing that copolyesters have been known for years, 40 or 50 years, is their chemical resistance, compatibility. And we look at this on an ongoing basis. We have an enormous database of chemicals that we look at, not only for our own interest but the interest of our customers.

And we like to use rather than pure tensile testing which is maybe not as applicable in the real world. We like to use what's called [inaudible 00:39:45] impact testing. So [inaudible 00:39:48] is a… It is an [inaudible 00:39:48] method. And basically what you do is you apply your material to a strained jig so you can typically use one and a half percent strain so that implies some stress it's been put on by the real world.

We then saturate a pad of cotton and put it on one side of the material. And so that's gonna induce some cracking or crazing if there's a chemical attack. That's represented in step two in the upper right-hand corner. And then we impact the backside of that flex bar, so the side that is not exposed to the chemical, in that way we can put the chemical exposure side in tension.

And what we do is represent this data in the form of retained impact strength versus a control that has been strained but has not been exposed to the chemical. And so this is just to run down. We won't go through each one individually, take way too much time.

This is an example of some common things that kept that all engineering resins are exposed to, and sometimes don't fare very well, starting with skin [SP] oil. So if you think of an headphone or an ear bud application, a lot of contact with skin oil polycarbonate, ABS, really suffer. Some grades or polycarbonate, I should say, and ABS really suffer.

Whereas Tritan, at least the standard flow in the [inaudible 00:41:23] are pretty immune. And you can go all the way down the line here. And what you see is that the Tritan family, there are things that are susceptible to, especially sunscreen. But the majority of the time, Tritan survives this exposure. And so we feel that, that really speaks to the durability of this resin in this type of space.

One example here of an applied stress is simply a one by one plaque that's had a hole drilled in the center of it, and then we put in a stainless steel bolt. And we torque that bolt to 85-pound inches of torque, and we spray it with Windex, the multi-used disinfectant cleaner that you'd see a lot in the kitchen.

And [inaudible 00:42:19] we'd set it out for 48 hours. And so you'll see the polycarbonate, because this is a clear plaque, you can see the actual stress cracking induced in the polycarbonate. Whereas the Tritan Copolyester doesn't crack. Now in an opaque housing you might not be able to see this, but that's what's happening in a lot of appliance failures. If you get a housing crack or a housing this starts to chip, it's actually this environmental stress cracking that is sort of masked by the opaque nature of the material.

So just to summarize toughness and durability, Eastman Tritan Copolyester has a unique combination of toughness, chemical resistance, and low stress level. We didn't talk about the stress level a lot, but that last slide kind of illustrates it. And Tritan allows brand owners to create devices with housings that will maintain their integrity to their intended life in the increasingly harsher environment.

Alex: So just to wrap it all up before we go to the Q&A session, I have one last video to show you. Tritan historically has been really known for being really tough, really clear BPA-free material that's used in a lot of dishwasher durable application. However, what we want to get across is there's a number of other applications and advantages to using Tritan in more opaque housings and in another type of application of [inaudible 00:43:47], none the least, reducing the sound and improving the sound quality of those appliances.

More importantly, you can use Tritan both in the jar and the housing of appliances and other parts as well. And if you use Tritan in both of those application, you actually substantially improve and enable a better acoustic performance in using one or the other.

And, ultimately, if you make products that consumers can enjoy more, that produce better, higher quality sound, they will appreciate that. They will value that, and that's ultimately what all the brand owners are looking for.

Trey: All right, guys. So we are actually going to move into our question and answer session. Now while we give both Alex and Steve a bit of time to review some of the questions that we've had come in, we've had a number of great questions already come in, so please do continue to send those. We've got some great technical experts on the line with us here.

Just a reminder, we will be sending you guys a copy of the recorded video presentation as well as the slides. So do be checking your email for that in the coming days. And we do have a short three-question survey that we would appreciate your feedback after the webinar. But we've had a number of great questions already come in. So we'll turn it back over to both Alex and Steve and we can get started with those questions.

Alex: Okay. Thank you, Trey. We had a good number of questions, so we'll try to go fairly quickly to try to cover them. So the first question was, for the frequency response factor that we talked about, how does that really correlate to 10 Delta from the DMA analysis, Steve?

Dr. Givens: Okay, so 10 delta is sort of a broad indicator of the damping response factor. It's not… I would say it's indicative, but it's not a good quantifiable relationship. So when we first started this work, we initially looked at 10 Delta, and we saw that we had, you know… We saw that we thought we had something that was interesting, but ultimately 10 Delta wasn't sensitive enough to give us the individual responses of these materials to the frequencies.

Alex: Thanks, Steve. So the next question is, for the damping analysis again, why not run that test of the same frequency?

Dr. Givens: Well, we don't run the test at the same frequency because motors don't vibrate at one frequency, right? So what we're really interested here… And things, sounds don't often happen at a single frequency. So when you speak, there's a variety of frequencies. When you listen to music, there's a variety of frequencies. When you run a motor, an electrical motor or even a gasoline-powered motor, there's a variety of frequencies that come out.

So blenders in specific, you start at a peak load, and then as the blade starts to engage the food and chop it up, there's a bunch of... There's a frequency range that all these things operate at. And so… And the other important… So that's the input. So all those frequencies vary. We wanted to see how that varied from the output. So we wanted to see, looking at these responses and through Amazon reviews and online reviews, you hear that some people really complain about certain blenders in the way they sound, and we wanted to understand that.

And so part of that is we looked at the entire frequency range that the motor could produce, and we looked at the entire frequency range that the human ear can hear. So that's why we ran it over these frequency ranges rather than at a single frequency.

Alex: Thank you. Okay, another question was, so you mentioned the damping is related to viscoelastic behavior. How do the long-term dynamic mechanical properties or also known as vibration resistance can break and compared to this?

Dr. Given: That's an excellent question. And I don't really know how to answer it.

So we've looked at depth into damping response factor, but I'm not at all sure how that relates. So something it’s… If you wanna contact me after the webinar, we can get into more in-depth conversation, even plans to generate some data. But right now, I just don't have any data to draw a conclusion with.

Alex: Okay. What is the intrinsic material character that differentiates Tritan from other materials to contribute to a better damping [inaudible 00:48:14] sound? Is it due to the specific formulation or something else?

Dr. Given: So we definitely think it’s due to the unique chemical composition of Tritan. So Tritan is a fully amorphous material, so there’s no crystalline structure even in small quantities. And that it’s made with one proprietary monomer that's kind of unique in its structure.

And we've been able to tie a lot of the damping response to that unique monomer. So you'll notice that in that first consideration, say in center-point impedance, it was comparing LEXAN Spectar, which is another Eastman Copolyester, and Tritan, and Spectar. The other Copolyester does not included that unique monomer.

So you'll notice that Spectar, while it was pretty good at damping, wasn't as good as Tritan.

Alex: And just to add to that, there's obviously various grades of Tritan available and the damping performance between the need [SP] grade of Tritan is not that different. So most of the grades will offer that same damping advantage and they will all differentiate from other competitive polymers. And so, the other question was about, specifically, UV resistance and specifically how do the colors react when exposed to the sun radiation.

Dr. Givens: In the opaque colors, they're fantastic. Like all copolyesters, like almost all clear engineered resins, exposure to sun causes a little bit of shift mostly to the [inaudible 00:49:59] end of the color spectrum. But we really don't see that in our opaque grades. So you'll notice the examples [inaudible 00:50:09] specifically or kind of that ultra white color. Some people call it corian white or a piano-black.

We've had those in testing for, I think, exposures up to probably 20 years. And we don't see a lot of color shift. So, very stable. We do have UV resistance packages. If you're going into a more harsh environment, like to say if you think about putting a blender on a deck in Venezuela or something, very near the equator, not a lot of cover. We do have UVI packages that are available.

Alex: And is Tritan UL certified?

Dr. Givens: Tritan is UL certified. We have HB, UL94HB grades and UL94B2 grade to Tritan.

Alex: Can you ultrasonically weld Tritan?

Dr. Givens: You can ultrasonically weld Tritan. One of our biggest applications, and probably our biggest single Tritan customer, everything they produce is ultrasonically welded. We've actually developed a pretty decent data package around that. We'd be happy to share it with you. So just contact one of us. We've got very specific guidance on power, the welder, fixtures to weld, the joint designs, and spatial requirements to ultrasonically weld Tritan.

Alex: Okay, and so obviously we presented a lot of data specifically comparing Tritan to materials like PC and PVC. What about comparing Tritan to Crystal polystyrene and specifically in terms of noise, frequency reduction as well as impact property. How would that compare?

Dr. Givens: So Crystal polystyrene, so we've talked about damping is a viscoelastic response. Crystal polystyrene definitely has a viscoelastic response but it tends to be a really stiff material. And so there's some relationship with modulus to damping and usually the higher modulus, the less well the material dampens. That's a very broad generality, but in the case of like Crystal polystyrene, it's definitely holds true. It's a stiff material so it doesn't dampen particularly well.

Alex: Okay, and how about the fatigue performance for a couple of copolyester?

Dr. Givens: Copolyesters, they fatigue very well. They have really good fatigue response at low temperatures down to -40C and up to probably 20 or 25 degrees below their glass temperatures so somewhere…or glass transition temperature, somewhere around 100C degrees. You know, they're extremely tough materials.

You'll see that reflected in their notch [inaudible 00:53:05] impact data. The one caveat is because they're amorphous, they don't stress crystallize. So fatigue is very good in a copolyester. The one caveat is if you're thinking about something like a living hinge, that is one place that we do fail.

So you might get two or three or maybe even 500 bands out of a living hinge, and then it's gonna start to neck. And somewhere north of that, maybe a thousand, you know, it's actually gonna fail. So we don't have the performance, that fatigue performance like something like an [inaudible 00:53:44], but for an engineering resin, it's pretty good.

Alex: When we recommend Tritan for container and pockets for refrigerators?

Dr. Givens: Yeah, actually Tritan does very well in a refrigerator. We're starting to move into the refrigerator space, and the crisper bands and egg holders and all sorts of things and the insides of the refrigerators. Again, it has very good low impact properties. That sort of ductile, the brittle transition in Tritan and Copolyester happens at very cold temperatures, somewhere -30C or -35C. So down to about -40C they have a very good impact properties.

Alex: Okay. Somewhat related questions. So what other applications beyond blenders might the acoustic properties, and then there's values that are important, too. So I'll weigh in on that obviously a little bit. Really, any product that generates noise specifically from mechanical vibration, that would be a big advantage, right?

So specifically, what we noticed is obviously in terms of appliance space, it's very important for appliances that produce very large amount of noise, like blenders for example, but it is also really interesting from the other perspective, appliances that either produce noise for a very long time, even though it might be lower level, there's a lot of value in that.

So we talked about dishwashers. Another example of that could be things like special robotic vacuum cleaners. You know, the new type of type of product category that tend to run for a long time, like an hour or two around your house, and even though right now for vacuum cleaners, we expect to not do anything else while you're using it. But now you have a robotic vacuum cleaner in the example, and it runs while it allows you to do something else.

You really don't want to it have a lot of noise while you're watching TV and it running. Other cases, especially anything that runs at night, any kind of appliances that runs at night, it becomes very important. So air purifiers, humidifiers, fans, those kind of things, and they all produce noise from mechanical vibration. And then by extension, anything that goes into the, like hospital rooms in the medical space, especially sleep apnea device and things like that that again are used at night and they have pumps and gears and motors.

So anything related to products that have motors and pumps and things like that. But then on top of it, Steve mentioned a couple. You can look into more acoustically related applications like headphones, especially with a microphone boom that could potentially transmit vibration and cause some feedback sort of into the microphone from the headphone. I don't know, Steve, if you have anything else to add to that.

Dr. Givens: Yeah. I think, you know, robotic vacuum cleaners, that's a great area. Also, regular vacuum cleaners, they're loud. My dogs hate them, so that might be an opportunity. Anything that runs for a long time. So we've even started to think about housings for compressors and say like a refrigerator. Also speaker enclosures, you know, there may be some advantages where… So you think, you know, historically, speakers were made out of wood, and now they've gotten smaller. And you don't have those big volumes to attenuate some of those noises that you don't want, so maybe it's more critical in the smaller speaker housing, especially things like a base module for the surround sound system, that I think that's an excellent opportunity.

Things like Bluetooth headphones, Bluetooth microphones for telecommunication, that's ... I think that's a good opportunity. We've seen that there are some advantages in that, reducing that sort of seismic interference that you get with a boom microphone. So that's all I could think of off the top of my head.

Alex: And then probably last questions, since we're almost out of time, is so for all those applications, can Tritan be used in more internal components as opposed to something like a housing in a jar, also help to reduce sound?

Dr. Givens: We have a large and vibrant compounding effort here where we’re starting to put things like glass fiber, and reinforcement, and carbon fiber reinforcement, things like nano clays. We started looking at Tritan blends. So Tritan blended with stiffer materials like ABS and polycarbonate so you can still retain some of that damping response but you can get a stiffer material, say make a motor base out of. Or if you need to gear or the spline [SP] or something to mechanically convey the energy from that motor to the blades in the blender or mechanically convey the power from the motor of anything to anything else. So if the driver belt in a vacuum cleaner or robotic vacuum cleaner, we started to develop grades of Tritan that can work in those applications.

Alex: Okay. Well, I think that was our last question. So thank you all for the great questions. And thank you, Steve.

Dr. Givens: Thank you, Alex.

Trey: All right, everyone. Thank you all for attending. Again, just a few reminders. We do have a short survey. We'd appreciate your feedback on. I also encourage you to check out some of the other Eastman presentations that we do have available on the Prospector Knowledge Center. A lot of great informative presentations there, as we do encourage you to check those out.

Again, we will be sending a copy of the recorded presentation and the slides. You can view that again and also share that with others at your company. But, everyone, thank you for attending and have a great rest of your day.