American Chemical Society AMA: I'm Marek W. Urban, professor and endowed chair of Materials Science and Engineering at Clemson University, AMA about stimuli-responsive, self-repairing polymeric materia

AmerChemSocietyAMA [1] and r/Science AMAs[1]

[1]Affiliation not available

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Thanks for doing this AMA! The self healing car paint that was reported a few years ago sounded really amazing. Where I live in Boston everyone's bumpers are in horrible shape thanks to street parking and probably the yearly influx of undergrads who've never had to parallel park before. A body shop actually told me it wasn't worth getting that part of the car repainted because it would be covered in scratches again in a month. So out of purely selfish curiosity:

How far away are we from actually seeing self healing paint being used commercially on cars and other products?

And could paint like that really stand up to the beating that big cities give to cars or is it more for the occasional superficial scratch?

firedrops

Thanks for asking. Well, one has to be careful because the paint you are referring to is good for so called mar resistance, not for self-healing. One of the automakers provides what they call self-healing paint as an option for about additional ~$1,000. Don't quote me on the price, which might be off, but this is what I have been told. The paint is simply more elastic, thus upon making a mar will bounce back with time. However, scratches will not go away. I would say 2-5 years we will see an array of products.

Prof. Urban,

When do you think the "average" consumer will own, or come in contact with their first self-repairing material?

Thanks you so much for doing this AMA!

ClaireAtMeta

Thanks for your question. Many companies conduct extensive research in this area. So it is matter of time and economics. I believe that within next 2-5 years we will have an array of products with self-healing properties.

Prof. Urban: Please give more insight about self healing polymers as in terms of polymeric structures and how they work.

I am a Clemson Graduate from MS&Eng (Polymer Chemistry). I worked as a RA/TA with Dr. Mike Ellison, Dr. Lickfield and Dr. Drews during my time at CU. Very happy to see our own Chair doing Reddit AMA :D

AdClemson

Go Tigers! Well, maybe next time. Thank you for your question. I refer you to the most recent publications, Y. Yang, and M. W. Urban, “Self-healing polymeric materials,” Chem. Soc. Rev., 2013, 42, 7446-7467. Y. Yang, X. Ding, M. W. Urban, Chemical and physical aspects of self-healing materials. Prog. Pol. Sci., 2015, (49-50), 34-59. If you cannot get these articles on line, check our website. All the best.

On the subject of Self repairing polymeric materials.

- Are these mostly additives that are mixed with a base polymer during molding, or is it a separate polymer class?
- What is the range of Rockwell hardness achieved by these polymeric materials?
- What are their regenerative limitations compared to my cutting mat at work that repairs nicks from my exact o knife?

edubsington

Thanks for asking. Typically, we modify existing materials, or apply additives to existing polymers. Our approach is not to reinvent new polymers, but add new properties to the existing materials. Rockwell hardness is in the same range as characteristic of a given polymer. The amount of modifications is minute, thus will not alter most of the macroscopic properties. All depends on the type of polymer and specific modifications. Yes, there are limitations, one of them could be how many times the same damage area can be repaired.

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edubsington

Thank you for your question. 1. Let me clarify this so everybody is on the same page. Historically, the very first self-healing polymers were based on diffusion of melted polymers (1980s). Next (1997-98), professor of architecture, Dr. Dry, reported the encapsulation method for using in creaked concrete materials to eliminate cracks in building. The same concept was proposed for the use in polymers

(2001). The approach replies on incorporating microcapsules with reactive chemicals which upon crack formation would spill the reactive liquid and crosslink. Industry rejected this concept because it is not very practical to weaken existing polymers with a liquid phase. Next, around 2007 and after, specific macromonomers were incorporated in order to facilitate stability of cleaved bonds upon mechanical damage which, it turn, were able to react and rebond. These may be reversible or irreversible processes and for the first time the sunlight was used to induce self-healing. Around the same time, supramolecular chemistry, such as coordination chemistry, H-bonding, ionic interactions, and host-guest interactions were utilized. In all these systems, with the exception of encapsulation, only minute modification of existing polymers were used (not mixed additives, but chemically modified polymers). Polymers don't self-heal by making and breaking bonds, but because there are reactive chemical entities available for rebonding. Also, soft polymers will not necessarily self-heal, but flow due to low glass transition temperature, which has nothing to do with self-healing. 2. In regard to your second bullet, Rockwell hardness is in the same range as characteristic of a given polymer. The amount of modifications is minute, thus will not alter most of the macroscopic properties. 3. All depends on the type of polymer and specific chemical modifications. If your cutting mat is soft it most likely flows and takes the original shape.

Prof. Urban,

I am a high school student who is considering chemistry as a major. What are some tips you have that might help me on my way? Also, what do you believe will be the main application of self-repairing polymeric materials?

Thank you! Hope to meet you one day!

oct1000

Thank you for your question. I delighted to learn that you are interested in chemistry. It is the most exciting and diversified field of study. In terms of the tips, I encourage you learn fundamental concepts and when in high school/college try to test those concepts experimentally under the supervision of your instructor. This field provides many opportunities; for example, you can work for one chemical company and have many different jobs (different projects), but do not need the change the company. But perhaps the most exciting part comes when you gain enough knowledge to conduct your own research and create new ideas. In regards to applications they are endless; from biomedical applications to paints, coatings, cosmetics, implants, you name it. Best of luck and consider coming to Clemson.

Hi professor, Paramedic here. Curious about the possible applications this could have in the medical field (of course, namely prehospital) such as skin mending and such. Do you see this type of technology crossing over to life-saving applications?

Egraydon

Hello, Thank you. Yes, there are numerous applications and extensive research is going on in this area. For example, implants or surgical tools, other biomedical devices.

Hello, thanks for doing this AMA.

I've only worked a tiny bit with polymers so this may not even be a valid question, but:

Can self repairing polymers be used as effective radiation shielding, on Mars for example? I know that hydrogen heavy materials are great for certain types of radiation based on their nuclear cross sections, but it would seem that powerful radiation would break up the molecules. Could such repairing polymers be the answer?

CincinnatusNovus

Thank you. Yes, any space mission will benefit from these materials, as there are limited opportunities for fixing materials in space. If designed properly, the presence of radiation may facilitate self-healing. We were the first to show that UV light can lead to self-healing. Also, the presence of certain atmospheric gases can facilitate self-healing, for example carbon dioxide. In terms of heavier radiation in space, the jury is out.

Hi, I'm curious about **how do you test these new materials for safety** before deployment in the real world? Just thinking about how many things could have contact with it - this task must be enormous! Do you just assume specific use case and ignore things that will not be present there? Or is there big list of popular chemicals you test against? And when you test - is it with computer simulations or in lab? Or maybe can you design it that only certain reactions will be possible? And finally what about complicated cases like when material is polluted or fragmented and inhaled or interacts with other nanotechnology in my soap etc...?

Second question: judging by the recent publications on Urban Research Group antimicrobial aspect seems to be quite important area of study. **What are the advantages over traditional antimicrobial coatings like copper?**

FeatureRush

Thanks for asking. How do you test these new materials for safety? The same as any other materials, which may vary from application to application, performance requirements etc. What are the advantages over traditional antimicrobial coatings like copper? The main advantage is that any plastic material can be modified to make its surface antimicrobial. For example, catheters or plastic implants. This important because according to CDC in the US alone, 100,000 people die from infections which are unrelated to their medical conditions.

North Dakota State University

Congrats, Bison!

Clemson

Ooo, sorry mate.

What are some of the targets/goals with the self-repairing polymers? I know we usually think on a pretty grand scale, but what are some of the stepping stones to more commercial products? Do they already exist?

swishmon

Thank you. Convince manufacturers that this is the future, and bring modern, R&D involving manufacturing to US. There is plenty of opportunities for novel materials.

I am no longer in school, and this is not my field, so pardon my ignorance. But if I may, where does the reaction energy in these materials come from? How do they initiate the 'healing'? Where does the activation energy come from, or are they favorable reactions?

joerobo

Thank you. The energy comes from the environment, typically temperature, electromagnetic radiation, other sources. The trick is to have reactive groups that can respond to the stimuli. Sometimes the researchers call autonomous self-healing, but what they really mean is that there is no human intervention. However, the surroundings, such a ambient temperature can sufficient for self-healing to occur.

Dr. Urban, thank you for doing this AMA!

- What sort of stress tests do you run and how do you determine the life-cycle of your polymers?
- Can they be safely broken down and disposed of?
- Can you recycle them?

Thanks again!

afishintheocean

Thank you. We conduct the same tests as for any other polymers, and more. We can utilize static or dynamic stress tests, all depends what we are looking for.

Hello Professor Urban,

I was just wondering what you think is "next" for us in the world of materials science. Is it graphene, polymers, or something else entirely.

Thanks!

zehamberglar

Well, this is rather general and good question. Of course it depends who you talk to, you will get different answers. If you talk to those who work in graphene, they will tell that this the future of materials. I don't believe so, but I think the future of materials will rely on how accurately and predictably molecules and macromolecules can be arranged together and are able to communicate with each other. Thus, signaling, responsiveness, and interactions with biological systems will be critical.

Hi there

I'm really interested in your course however I don't work in the industry and the price is really high.

Is there any free courses or books you can recommend to give me an introduction to polymer coatings?

JazRad

I am not aware of any. There are books, but that's not the same as the first hand instructor knowledge. Sorry.

Thank you for your time. As a prospective chemistry graduate student interested in the interaction of nanomaterials and the environment I have a couple of questions:

1. How much thought do you and your group give to the full life-cycle of your polymers? As most materials end up in the environment towards the end of their life-cycles, does you group consider biodegradability or toxicity when synthesizing novel materials?
2. For self-repairing coatings, what kind of weather conditions (such as extreme cold or heat, high or low humidity) do these materials perform their best, and what conditions generally lead to poor performance?

KazerothMkII

Thank you and good luck with your graduate studies. 1. There are two aspects to this issue: recycling, which implies designing polymers so they will not harm environment upon degradation, or can be reused in a different form. The second issue is sustainability that is designing polymers so they can last for a long time while maintaining original properties. Economically, the latter will lead to lower consumption. 2. All depends on a particular polymer and applications; for example, polyurethanes are very durable and are often used in transportation industries because of their ability to perform under different conditions. Polyesters, on the other hand are not that durable under extreme conditions. But all properties are dictated by their building blocks, molecules.

Prof. Urban, do these coatings have the potential for E-Beam treatment? Also do you think there is potential for this product in the decor paper/furniture industry?

speedy621

Thank you for your question. Yes, it is just a matter of chemical designs and formulations. E-beam facilitates crosslinking which is the energy source for chemical reactions. There are no restrictions as to why self-healing paper or furniture coatings could not be used. It is all in chemistry, not necessarily in applications. Very often the cost is the main factor. Our approach is not to reinvent new polymers, but add new properties to the existing materials.

Hello Prof. Urban! Thanks for doing this AMA!

Material Scientist here working in the thermoset composites industry. Are there coatings developed yet that can *deflect* heat as opposed to withstand it? Thermoset composites do a great job of withstanding high temperatures for a long period of time, but do nothing for deflecting heat radiation.

jkostry

You are absolutely correct, but I don't have a good answer. I could envision multilayed or stratified materials, but this is a long shot.

Prof. Urban,

How much of your research is focused on the fundamental science behind polymer physics versus the production/manufacturing? As a researcher, how much do you feel obligated to contribute in that regard?

(I'm asking as I was trained as an engineer, and am now doing scientific research, which is much less application-heavy)

Best regards

i_dont_actually_like

Thank you. Indeed, we are mostly focused on fundamental aspects, lees production/manufacturing. We are interested in understanding fundamental processes that govern materials behavior, and through this process, design new materials with attractive properties. Although both are important, it is a matter of interest and priority. Being in academia, I feel that our responsibilities should lead to new discoveries, and production/manufacturing is more applied. However, there is plenty of room for outstanding research in production/manufacturing, which should be a paradise for engineers. The problem is the industrial R&D is very limited.

Hi Dr. Urban!

I don't necessarily have a question for you; but I did a summer internship in your lab during my undergrad back while you were still at USM. I worked with one of your graduate students to modify medical grade polymers with antibacterial/microbial agents in order to decrease the likelihood to get infections while in the hospital. The time I spent in your lab as well as the work I did was the reason I chose to go to graduate school! I am now in my fourth year of grad school and I only have you to thank! I am glad to see you are doing so well and that your research has continued to impress! Thank you for the opportunity to work with you and propelling me into my career.

jonessk11

Many thanks for your kind words. It means a lot to me. I am also delighted to learn that you will be graduating soon. All the best and stay in touch.

Prof Urban, Would you please comment on the survivability of the self-repairing systems you work with in standard sunlight (i.e. UV exposure)? I'm wondering about corrosion barrier systems for reduced maintenance applications (wind mills, off shore drill rig structures, etc.). Thank you very much.

AlphaSquare

Thank you for your great questions. There are no detailed studies in regards to durability; just sporadic reports. Without specifics, I can tell you that there is a lot of research conducted in this area. In terms of UV exposure, we conducted several studies which utilize the Sun for self-healing and it turns out that the presence of UV absorbers or HALS will slow the process of self-healing down, but will not inhibit entirely.

Hi Prof Urban,

Just a few weeks ago I was reading a small article in ACS central science about self-repairing concrete that integrates bacterial spores that can respond to cracks in the concrete by producing more limestone. You draw inspiration from nature in your work but have you ever considered including or actually included whole organisms in your stimuli responsive materials? I would love to hear your thoughts on how feasible this might be.

xmasjacksonflaxon

Hi, and thank you for your question. Yes, we have done some of the work, for example, using macrophages, but there are a number of complications and obstacles, which are system dependent. I realize this is very general answer. The devil is in the details.

Prof. Urban,

You mention your aspiration of designing living systems and taking inspiration from nature. As a biologist, I find it disappointing that the design principles of your work and other similar fields, like supra-molecular chemistry, are not being broadly applied to understand biological systems better which seems like a real missed opportunity for both disciplines. Can you propose how nanotechnologists and biologists can better collaborate in the future, or any venues you are aware of that do so effectively now?

Thank you

casseroleking

Thank you. You are bringing a good point which I address in a second. However, I am not sure I understand your disappointment. As you stated, the design principles of supra-molecular chemistry in materials are not being applied to biological systems. Should this question be addressed to the biologists? I am the materials guy. By the way, we utilize covalent bonding as well. I entirely agree with you that there are many opportunities for both disciplines, biology and materials people to work together. I can envision several avenues for these disciplines to collaborate in the future and will be more than happy to explore them. I am aware of the NSF activities within DMR, but in my view the logical step would be for materials and biologists to address these issues with NIH or other government agencies. Again, I will be happy to pursue it.

Good morning!

I work in a plastic injection molding plant in the automotive industry. We use a MI7 material on several components. After these parts sit in a closed tote for a day or so, they begin to emit an incredibly foul odor. It's this witches brew of scents - roadkill, brimstone and poison.

It's obviously sulphur, but, for the life of me, I have no idea why it occurs so much in these products. My techs are somewhat concerned that it could be a health issue. I know this isn't your area, but do you have any pointers?

PerendiaEshte

Good afternoon. I suggest you contact your safety officer and determine the source of the odor.

These materials are indeed interesting and as such I am looking forward to learning more about them.

I am also very interested in what often has not been taken into account when developing new polymers: their environmental impact. So I'd like to know:

What is the environmental impact of the production?

Are these materials recyclable?

Is degradation possible? If so, do they just break into smaller pieces or do they turn into other compounds that are not pollutants or pose health risks for the ecosystem and humans?

Thank you

luxux3

The same as any other production. There are two aspects to this issue: recycling, which implies designing polymers so they will not harm environment upon degradation, or can be reused in a different form. The second issue is sustainability that is designing polymers so they can last for a long time while maintaining original properties. Economically, the latter will lead to lower consumption.

Similar to how 3D printing of synthetic materials has crossed over to biological and medical applications such as 3D printing using cells to make heart valves, etc., do you see any possibility in this ever crossing into those fields to, for example, create like a wetsuit type thing that if pierced and a wound is created underneath, could self heal, or even less fantastical, some sort of cell spray to heal wounds?

jish_werbles

There are many possibilities and ideas, and even more applications. Your comments are certainly are worth exploring.

Hi, Prof. Urban,

MSE grad from Clemson (2007) here, thanks for doing this AMA. My question is rather general, but one I always like to ask researchers.

I see that you say that your research takes inspiration from nature. My question is, how do you actually go about finding your inspiration?

red_wine_and_orchids

Many inspirations are generated by reading and thinking what Nature has to offer and ask questions why? Others come from overall chemical knowledge and again, asking and questioning why?

Thanks for doing this AMA, Professor Urban! I'm a chemistry undergrad that is interested in pursuing materials science and had a question. Are there any plans to apply these polymeric materials and coatings to space technologies (spacecrafts, suits, etc.), and if so, would an expanse of the space program be more feasible due to cut costs from repairs?

VorpalSingularity

I hope so. Of course these decisions are made by the agencies and the companies involved in space programs.

I am in my first year of university doing pharmaceutical chemistry. I am very interested in MSE but decided I liked this more. Do you think it is a field which is useful/easy to learn about on the side (the actual courses are restricted to MSE students)? Thank you!

dkja

Hi. In pharmaceutical chemistry you primarily design, synthsize, and characterize drugs. In materials science you design, synthsize, characterize, and apply materials to solve specific problems. There is a number of similarities; the difference is that materials are much broader and require the knowledge of chemistry and physics. Therefore, job opportunities are very diversified.

Prof. Urban,

What area of a average person's life do you feel would be impacted the most by widespread use of self-repairing polymeric materials?

Thank you for doing this AMA!

intellectual_bacon

I think everybody at some point will need medical assistance. The availability of life quality improving devices whatever they are, will be critical. Also, our daily surroundings, such as furniture, computers, phones, etc. will be scratch free.

Good Morning Teach! Thanks for doing an AMA! Is it a feasible application hope to think stimuli responsive materials could be used to change the shape of airfoils in aircraft in flight? Is this already being done?

UltrAstronaut

Thank you. Interestingly enough, we work on materials that 'remember' their shape, so if one can program materials to change its shape in a coordinated manner, airfoils in an aircraft can be also changed.

Hi Pr. Urban

What do you think will be the most "extreme" use of this technology?

ben-irl

I am not sure what you exactly mean, by 'extreme,' but I am going to guess. I think you mean the most challenging. The development of materials that self-heal at super high temperatures is perhaps one of the most challenging aspects of this research. There are of course others.

Hi there!

How far away do you think these products are from being using on car bodies? Could it eventually fix cracks in windows? Do the elements effect the rate of repair is there a certain temperature and moisture level that helps?

CoolLikeAFoolinaPool

Not that far. Automakers need to encourage materials manufacturers to produce these materials

Hello! I am currently studying Polymer Science and Engineering as an undergrad. Any tips for me about the work?

pjokinen

Thank you and good luck with your studies. One advise I can give, learn fundamentals how to design polymers from molecules; you will get a lot of mileage down the road when you know how to synthesize polymers.

Hey Dr.Urban I am an undergrad chemistry major. I was wondering how you are going to place these self healing polymers onto a surface and whether that would change any of their properties.

Ize200

Thanks for your question. Yes, these materials are typically on surfaces and the idea is to protect the substrate.

Can you explain in simple terms how the self repair process works?

Vighy

Thank you. In simple terms, when chemical bonds that make up a material break, and are able to rebond again, self-healing may occur. That's very simple answer, but the process itself may be very complicated.

Professor Urban, nothing to do with self healing polymers: but.. We used a chemical polymer (polyethylene glycol, cannot recall the molecular weight) in my immunology course when we wanted to isolate antibodies from a simple chicken egg. Subsequently I began to see it in everything from my toothpaste to personal care products, in my mouthwash and it is even the active ingredient in the eye lubricant drops that I put in my eye. I became curious as to how this compound would be produced and if there is a market for creating it and selling it to one of the many various companies which use it in industry, medicine, or cosmetics. I therefore have a number of questions:

1. How difficult is the basic production process of this compound, i.e. what sort of equipment would be required and how elaborate or difficult of a process it it?
2. What makes it such a fantastic polymer that is it so widespread in products that you see day to day? Why would people put it in their eyes?
3. Why is it used in our antibody isolating process?
4. How would the molecular weight be made to precise amounts instead of it fluctuating wildly?

discgolfpro

Thank you for your questions. 1. PEG is relatively inexpensive and the process is well established. It is typically produce by cationic and anionic polymerization of ethylene oxide. 2. PEG is an eye lubricant, like an artificial eye tear and do not evaporate as quickly. 3. In its PEGylated form is a non-ionic surfactant which forms vesicles as drug delivery systems. Thus, it can be use to isolate antibodies and other less water-soluble components. 4. These living polymerization methods (anionic and cationic) precise molecular weight control.

Good afternoon Prof Urban,

My question is how do you evaluate your polymeric materials and coatings? Are factors like coating thickness, structure and porosity important in the development of your coating and how do you go about measuring these factors if you do?

Also, how do you also measure the self healing ability of your material? Do you cut an area, let it heal and then investigate a cross section under microscope?

I recently did an investigation into the porosity of a tungsten carbide coating of steel and found great differences in porosity measurement between standard cross sectional analysis and another preparation method that doesn't cause any smearing/pull-out.

Thanks for contributing and doing this AMA.

- Your friendly neighborhood SEMTech

Tia_Avende_Alantin

Thank you for your question. These are important parameters which often effect self-healing effectiveness. We evaluate by varying many parameters, one at a time, and measure geometrical changes within damage as a function of time/temperature, etc. There are several types of measurements: 1. Macroscopic, typically using optical or electron microscopes, and 2. Molecular analysis, in which we utilize chemical imaging, allowing us to determine molecular events responsible for self-healing, and 3. Mechanical analysis, whcih could be static or dynamic.

Hi! Mahalo for the AMA.

How "self-repairing" is your plastic? Really curious about that, particularly for sunglasses.

some_random_kaluna

Mahalo for your question! just visited your neck of the woods. It was beautiful. I guess I answered in one of the questions posted by somebody else. For sunglasses, the idea is to make scratch free lenses. Very doable.

Which one of these self repairing mechanisms do you see most useful in constructing self repairing dielectric elastomers?

DielectricElastomer

Which mechanisms are you referring to?

Hello Professor,

On your nature-inspired studies, have you worked with mussel-like coatings such as polydopamine or other polycathecols? What kind of potential do you think this technology has for industries such as aerospace?

Looking at their applications as a platform for further functionalization, ability to stick to a wide variety of materials (metals, ceramic, polymers), even while underwater, and easy "dip-coating" processing, they seem like a great intermediary for self-repair and stimuli-responsive applications although it seems most of its research has been focused on the bio-medical field.

Broadly speaking, what are some common challenges you face when developing self-repairing or stimuli-responsive materials? Is there some particular property (temperature perhaps) or technology limiting you?

Any wishes for the New Year?

Thank you for doing this!

Kapsyx

Thank you asking. Yes, we have patented these technologies, in which DOPA and self-healing components are integrated into one system. And a Happy New Year to you, too.

Hi Professor, thank you for doing this AMA. I am planning to study Chemical Engineering and Materials Science starting in September so this is an area of great interest to me.

I have recently read 'Made to Measure: New Materials for the 21st Century by Phillip Ball' (published in 1999) and there is a chapter focusing on Smart Materials where he describes the possibility of: "an aircraft wing made of a substance that changes colour when and where microscopic cracks develop? or even one that automatically heals those flaws?"

My question would therefore be: How close have current developments such as self repairing paints brought us to being able to develop completely self repairing polymers?

SparklingBanana

Thanks for your question. The materials that change color upon mechanical damage are available. The question is the cost. I would say 2-5 years and these products will be available.

What do you think about the Grey goo scenario? Being intelligent about self-repairing responsive coatings I'd be interested to hear your take. Do you think there is a *real* possibility of something like this happening should the wrong puzzle pieces be put together?

Grey goo (also spelled gray goo) is a hypothetical end-of-the-world scenario involving molecular nanotechnology in which out-of-control self-replicating robots consume all matter on Earth while building more of themselves,[1][2] a scenario that has been called ecophagy ("eating the environment", more literally "eating the habitation").[3] The original idea assumed machines were designed to have this capability, while popularizations have assumed that machines might somehow gain this capability by accident.

speedofgravity

Very interesting, although I must admit I don't see it coming soon because there are so many chemical and physical processes that the Nature mastered, and we know so little about them that it will take quite a bit of time to figure it out. Of course, chemically many things are possible, but deliberate design of robots which involve physical and chemical processes will be a challenge. Also, the fundamental difference between living and non-living systems is the ability of the former to metabolize. It will take some time to fully understand that.

What sort of bonds are being broken and healed?

referendum

Thank you of your question. Practically any bonds can break, but only those will rebond which are chemically active.

Hello Prof. Urban, could you expand on what you mean by stimuli responsive. What kind of responses have you been able to produce in response to a stimuli? (Shape change, color change, reaction?)

Along the same lines, what kind of stimuli are you studying? Is it possible to have material systems that are highly responsive but still stable in ambient conditions?

What are some applications you envision for commercialization in the near future and what kind of time scales for response can we expect?

Thank you for the AMA!

Dizzymonkey36

Thank you for your question. We interested many types of responses, which are in general classified as chemical or physical. Indeed, the material must be physical and chemically stable until a given stimulus is applied.

What did you think of the game last night?

namkrav

It was a good game. I wish the score was more favorable for Clemson.

Is any work being done on lightweight, strong, radiation resistant polymers that might replace structural metals for space applications?

If so any info or links? If not, any info on the problems hindering development of such materials?

Replacing for instance aluminum with a light polymer with similiar or improved properties would lower launch cost and further help the industrialization of space.

rhex1

Thank you. One example is the Dreamliner (carbon/graphite fiber composites) There are many others that NASA might be interested in. These are however not the cost reducing materials. They are lighter and stronger, and most importantly, fuel efficient materials due to lower weight.

Hello! I was wondering about how stimuli responsive polymers could be used to replicate parts of the body, such as cell membranes? Is it possible and how would it work? Also, would it be therefore possible in the future to use these polymers in 3D printed organs as a scaffold for living cells to grow on, or as a permanent artificial membrane that stays in the body? Thankyou for doing this AMA! I am researching bioprinting for some schoolwork and would greatly appreciate your input.

elyzx

Thank you. Yes, I believe a number of labs work on 3D organ printing. There are several polymers that come to mind (pNIPAMM) which exhibits temperature responsiveness, or DMAEMA. There are others.

Hello! I was wondering how much research goes into products that coat medical implants. I have an implant and am rather nervous about PTFE and PFOA coating the lead wires of my neurostimulator. When I ask questions about this it seems the only answer that I get is that it is safe - but my question is how is it tested to ensure safety for the life of the product (usually 10+ years)?

littleleaf14

Hello, and thank you for your question. If you have concerns, I suggest to check with the manufacturer. However, I am certain that FDA would not approve the device if there were any issues. You may also contact FDA and request information on this particular material/devise and how it was tested.

I realize that this is probably not a question in the scope of this AMA, but here goes: I have a B.Sc in chemistry and an M.S. in materials science and I'm having a little trouble finding a job. It seems like all positions want Ph.Ds (national labs) or simply reject me immediately (industry). Can you make any suggestions about how someone just beginning their career could make themselves look more attractive to potential employers? Thanks!

onlypostscalligraphy

HI. Make sure you present yourself, both on paper and in person. I find this surprising, but I would look into smaller companies which often prefer MS over PhDs. The national labs is a different story. Best of luck.

First off, thanks for taking your time to do this AMA. I have a question about these self-repairing polymers : Do they heal automatically or do they need to be treated with some sort of reagent(acid/base/metal catalyst) in order to begin the process?

funymouth

You are welcome and thank you for your question. Many systems require some sort of stimulus, such as temperature, radiation, and some will self-heal without intervention, all depends on the chemistry involved. Majority of polymers to form crosslinked networks require catalysts and other reactants, which may or may not participate in self-healing.

Hello Dr. Urban. I'm and undergrad and soon I'll be starting undergrad research. One of the professors I'd be working under pretty much exclusively works in polyphosphozenes. Do compounds such as these show a lot of potential in materials? I'd like my undergrad research to serve as a springboard for graduate school studies so I want to make sure its a relevant area I'd be working in.

Psilocybear

Thank you for your question. Polyphosphozenes are very interesting materials and have many already established applications. They offer very versatile chemistry with many uses.

Best of luck in your research.

Did you have a chemistry set as a kid? If so, what is the coolest experiment you remember doing? How do you think the loss of true chemistry sets for kids will impact chemistry in the future?

eye_can_do_that

No, I did not. You raise a good point though. I don't know, but unfortunately chemistry does not have the reputation it use to have. On the other hand, ACS does an excellent job in promoting the good site of chemistry. How to we get kids interested in chemistry? It seems that this chemistry teacher and the curriculum design is the answer.

Hi Dr. Urban,

I've had the chance to work with a lot of cool materials scientists from Clemson, so I'll just give you the credit for shaping them into great people to work with. Thanks!

What sort of stimuli have you researched for responsive materials? Are there any you find more interesting or challenging than others?

SpookyWagons

Thank you for your comment and I relate this to my great colleagues. We use all kinds of stimuli, in general chemical and physical. You can find on our website all specifics. All the best.

Thank you for taking the time to talk with us!

As a chemE working in the flexible packaging industry, I'm curious about potential use in self healing pouches or semi-rigid systems. Do you see this as a feasible application of your work, or do you foresee things such as cost and processability preventing market penetration?

feastofthegoat

Thank you for your question. Yes, I can envision it, but cost is always an issue.

How promising are bio-polymers made up from say, switchgrass?

THORN-TON

Thank you. I really don’t know much about switchgrass, but the use of biopolymers is always an interesting project to investigate. One of our first self-healing polymers utilized chitosan, which is a derivative of chitin. Chitin is polysaccharide naturally occurring in nature (crab and shrimp waste).

What kind of chemicals are used to manufacture these coatings? Are any of the chemicals toxic to mammals? Do the coatings contain toxic chemicals or residual amounts of toxins in the finished product? What do they smell like?

Chauncy_Prime

What kind of chemicals? Any chemical can be toxic or non-toxic, and there are safety guidelines for handling all chemicals.

Have you used any of these polymers in 3D printing filaments or 3D manufacturing? If so, do you have trouble with these types of polymers do to their self repairing nature?

CavalierEternals

Thank you. There are many outstanding opportunities for 3D printing of self-healing or stimuli-responsive materials. Good point.

With your research into polymer. How much closer does it bring powered combat exoskeletons. In terms of performance I'd like to know how polymer compares to kevlar, ceramic, and depleted uranium in terms of taking a shot and keeping the man inside safe?

tobias-tonzing981

Thank you for your question. Polymer properties vary, and depend on molecular structure of monomeric units. Kevlar is also a polymer, and one to the toughest ones. There are other polymers that will withstand quite a bit. Actually, some polymers are used to make bullets. Pretty tough stuff.

Are you/have you integrated MEMS (Microelectromechanical systems) into your research? I'm by and far no expert, but it sounds like something that would work well together.

ModestMariner

Not really. We are primarily interested in chemical designs and physical aspects of self-healing.

What advice would you suggest to someone in highschool trying to get into chemical engineering? In terms of both things academically and at home.

cheesepuffs90

Study hard and make sure you are good in math. Math is the foundation for any engineering and science majors.

Where does self healing polymer get the energy to reform it's bonds? I assume hydrogen bonding or ionic in these cases?

Also why are you doing the Ama?

neuromorph

Not only. I encourage you to look into one of the review articles on the subject matter.

Thanks for answering our questions! Would you be able to tell us about the most exciting advancement you've had in your research recently?

clairemm

Not really. Most of the work we do is confidential.

What's the best way to get involved with this type of research starting as a layperson?

JustFuckinUsernameMe

Learn fundamentals of chemistry and physics. I really cannot answer without knowing your background.

Does chemical engineering aspects ever come into play during your research? Do you ever work with chemical engineers?

snoopsquires69420

Sure.