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Research Article

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Mechanical and Thermal Properties of Polyurethane/Epoxy IPN's

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Abstract The Interpenetrating polymer networks (IPNs) were prepared from polyurethane and epoxy. The polyurethane-toughened epoxy was developed. Epoxy had toughened by weight fraction of 10, 20, 30, and 40% Polyurethane resin. PU–epoxy matrices were characterized for their mechanical behavior and thermal properties. The results show that the mechanical strength and mechanical modulus are lowered through the introduction of PU into the epoxy matrix to form the IPN structure. As the polyurethane content increases, the tensile strength and flexural strength of the IPNs decrease. The specific heat capacity and thermal conductivity have been affected with the PU percentage.

Keywords Epoxy, Polyurethane, Interpenetrating polymer networks, Mechanical properties, Specific heat, Thermal conductivity

Introduction

About half of the world's population makes use of the internet daily. However, very few of these users are aware of the environmental implications of using information technology devices and the internet infrastructure that supports these devices. This has greatly contributed to the greenhouse gases being generated daily on a global scale. These ranges from the devices used to power these information systems to the gas emissions as a result of the heat generated by these information systems. This is mainly due to the lack of awareness within the industry as regards these environmental implications.

A small amount of carbon is emitted for every bit of data sent and received over the internet by a user's device from the servers that process these data. The amount of carbon generated by a single user appears insignificant but when the total number of internet users all over the globe is considered, this creates a serious concern due to its contribution to the greenhouse effect. Therefore, there is need to reduce unnecessary internet activity, as this will contribute to the overall reduction of the greenhouse effect.

Green computing is the study and practice of using computer proficiently [1]. The objectives are similar to those of green chemistry [2]; that is to reduce the use of hazardous substances, maximize energy efficiency during the product's life-cycle, and advance recyclability or biodegradability of defunct products and factory waste. Taking into consideration the popular use of information technology industry, it needs to lead a transformation of sorts by turning green in a way no industry has ever done previously. It merits underlining that this "green innovation" ought not to be just about awareness to spur environmental activists' yet solid activity and hierarchical approaches. Openings lie in green innovation more than ever in history and associations are considering it to be an approach to make new benefit to communities while attempting to support the ecological reason. The plan towards green IT should include new electronic products and services with optimum efficiency and all possible options towards energy saving [3].

The green computing concept started in l992 when the United States (U.S.) Environmental Protection Agency (EPA) propelled Energy Star; an intentional marking project to advance and perceive energy effectiveness qualities of electronic equipment, such as monitors, climate control equipment and other technologies [4]. This

prompted an across the board appropriation of sleep mode on commercial hardware [5]. As indicated by an estimation given by the U.S. EPA, incorporation of sleep mode in computers reduces their energy consumption by 60 to 70 percent (%) [6]. Green computing alludes to the practice of maximizing the efficient use of computing resources in order to limit greenhouse effect. These incorporate the objectives of controlling and lessening the environmental footprint of a product by minimizing the usage of water, energy, hazardous materials and other scarce resources, notwithstanding limiting waste from creation and all through the supply chain [7].

Green IT (Information Technology) indicates environmentally stable IT which alludes to the study and practice of the plan, production, use and removal of computers, servers and related subsystems ingeniously and effectively with almost no effect on nature. Green computing fills in as advantage to nature by improving energy proficiency, empowering reuse and reusing, utilizing less harmful materials and diminishing ozone depleting substance discharges [6]. Greenhouse gases (GHGs) are polyatomic particles which include: Carbon dioxide (C02), Methane (CH4), Nitrous oxide (N20), water vapor (H20), Ozone (03), and Chlorofluorocarbons (CFCs); the ozone draining synthetic compounds. Greenhouse gas is any gas that traps heat in the environment by means greenhouse effect [8].

Carbon footprint refers to the measure of greenhouse gases, estimated in units of carbon dioxide, created by human activities. A carbon footprint for an individual or an organization can be estimated which is normally given in huge amounts of carbon dioxide comparable (CO_2e) every year [8]. A Gartner study reports that Information and Communication Technology (ICT) represents roughly 0.86 metric giga-huge amounts of carbon dioxide (CO_2) discharges yearly, or pretty much 2% of worldwide carbon emissions notwithstanding greenhouse (GHG) outflows and e-waste, which are a portion of the impacts of ICT to specify a couple on ecological sustainability [9].

This examination is on two major greenhouse gases (GHGs) which are carbon dioxide and nitrous oxide. Normally, green registering frameworks or items consider the so-called triple bottom line of people, planet, and benefit. This varies to some degree from conventional or standard business practices that focus mainly on the economic viability of a computing solution [9].

Literature Review

A 2016 report by Jim Hart of the University of Edinburgh recommends that by delaying the life span of the computers, less computers should be bought consequently lessening producer's interest on raw materials, transport, energy, and so forth. This will prompt decrease in carbon emission within its supply chain. This delay in the acquisition of a new computer also usually represents a delay in taking an opportunity to swap an old device for a (potentially) more energy-efficient replacement. Therefore, there is a risk that this may lead to a higher carbon emission [10].

The term carbon footprint is a well-established concept usually understood as the life cycle carbon equivalent emissions and effects related to a product or service. The carbon footprint, its relative magnitude and the development trends are important matters to study for any sector due to the growing concern of global warming. In 2016, experts associated to the World Economic Forum ranked global warming as the no.1 threat to society and the economy [11]. For the ICT (Information and Communication Technology) and E&M (Entertainment and Media) sectors, there is a strong connection between carbon footprint, the energy consumption, and the supply of energy, which makes it essential to likewise consider the energy consumption.

The study, [12] assessed the worldwide carbon footprint of the ICT and E&M sectors. The extent of the ICT sector's carbon footprint and its footprint in contrast with different sectors has been discussed for some years, both among researchers and in the general society. In [13], the expected development of the ICT carbon footprint is depicted as high and expanding, for the most part dependent on the assumption that the ICT sector’s carbon and energy footprints are developing fast and in accordance with the exponential information traffic increment. Assessments like these are typically founded on restricted and additionally false information, frequently of a particular age that exaggerates the ICT footprint. This is the motivation behind why top to bottom examinations and broad data collections are expected to make a superior comprehension of the energy and carbon footprint identified with any item, administration, or the entire area. As per the authors, this is best

accomplished if the examinations depend on as many examples of estimated data as could reasonably be expected. Consequently, wide data evaluation and studies are expected to get precise appraisals of the ICT part's energy and carbon footprint and to keep up an all-around established and modern view on their improvement [13].

As of recent, some studies have evaluated a developing energy and carbon footprint for the ICT sector [14]. However, in 2016, an examination for Sweden [15] saw that the energy and carbon footprint of the ICT and E&M divisions had surged around 2010 and afterward began to diminish, in spite of developing number of use (information traffic), as appeared in figure 1. The spotted line shows the emissions if world normal power blend would have been used rather than the Low-carbon Swedish blend (Mainly dependent on hydro and atomic). Comparative diminishing energy uses inclines as in Sweden have additionally been accounted for Germany and the US.

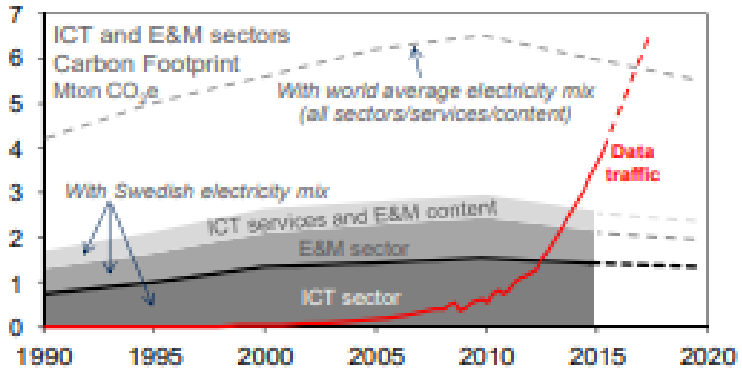

Figure 1: Total carbon footprint results for the ICT and E&M sectors in Sweden in 2015 [15]

Figure 2 shows the results of two recent studies estimating the electricity consumption of the ICT sector in Germany [16] and data centers in the US [17] combined with a study on the electricity consumption of consumer electronics in the US [18].

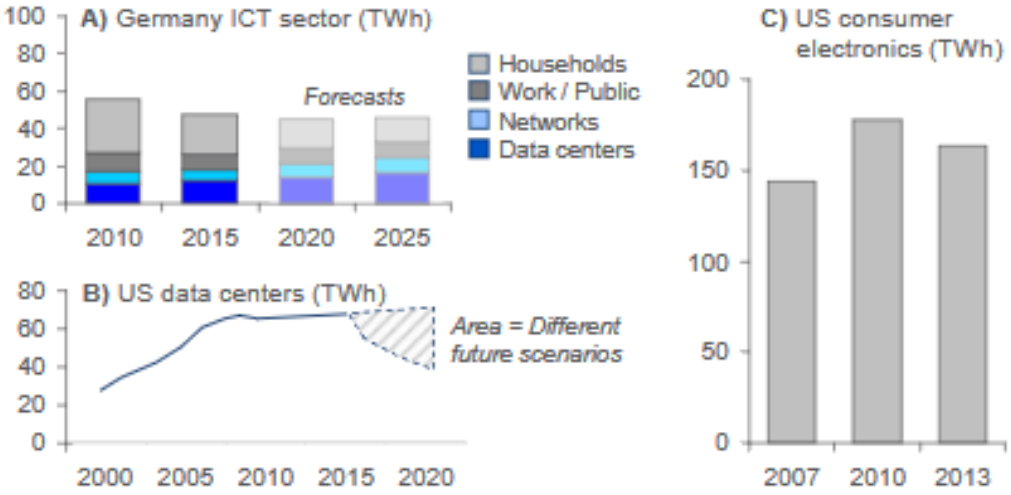

Figure 2: (A) Total electricity consumption of the ICT sector in Germany including TVs and other consumer electronics [16]. (B) Total electricity consumption of data centers [17] and (C) consumer electronics [19] in the US.

Note that the unit and scale of the Y-axis is the same in figure (A–C).

A significant advancement that has been distinguished in previous papers by the creator, [15], is the presentation of the cell phone and comparative terminal stages, which replaces more seasoned, energy wasteful equipment and arrangements, and makes all the past just as extra new administrations accessible by means of one single stage, just by downloading programming applications, i.e., "applications". In this way, various functionalities,

(for example, morning timers, number crunchers, guides, and so on), which recently required separate items and equipment, have been supplanted by one single gadget which, what's more, can be refreshed with extra functionalities after some time. This has without a doubt been a transformative change for the business just as for the clients.

The research authorized by OVO Energy, the UK's driving free energy supplier, features that very nearly seventy five percent of the UK (72%) are totally unconscious of the carbon footprint connected to their inbox. With more than 64 million pointless messages sent each day because of lack of control, computer clients are contributing 23,475 tons of carbon a year to the UK's footprint. Their report shows that while messages are an indispensable type of correspondence in the present world, it would show up they're not constantly worth the subsequent carbon emanations. The report indicated that every UK grown-up sending one less 'thank you' email a day, would spare more than 16,433 tons of carbon a year - equivalent to 81,1522 trips to Madrid or taking 33,343 diesel vehicles off the street [20].

While the carbon footprint of an email isn't enormous, it's an extraordinary representation of the more extensive rule that removing the misuse of our lives is useful for our prosperity and useful for nature. Each time we make a little stride towards changing our conduct, be that sending less messages or conveying a reusable espresso mug, we have to regard it as a suggestion to ourselves as well as other people that we care considerably about the huge carbon decisions [20].

Current Strategies to Reduce Computer Based Carbon Foot Print

OVO Energy created the world's first carbon reducing Chrome Extension - Carbon Capper. When downloaded, the extension identifies when the user has hit send on a potentially unnecessary email, sending a prompt to ensure more thoughtful email traffic. The Extension tracks word count, flagging emails under four words, and allows users to keep a close eye on their individual email carbon footprint. The extension is available for download from the Chrome Web Store [20].

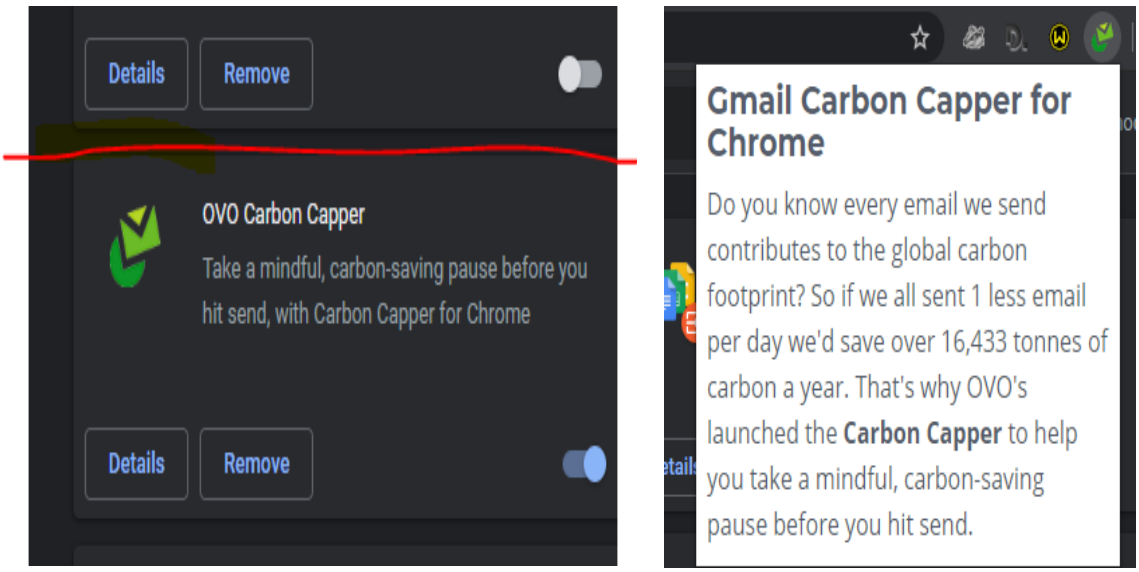

Figure 3: Screenshot of the Carbon Capper Chrome Plugging Source: Chrome Browser

Asides, sending emails, simple actions on social media such as like, comment, share, follow, etc. still play a similar role in increasing our carbon foot printing. Facebook initially gives users the privilege to share a contact's visible post, irrespective of the privacy presences; a) share with public or b) share with just friends).

But currently, a user can only share a contact's post if the privacy settings is set to public. This is because a user's post that is set to only be visible to friends needs no extra sharing because that action will in no way increase the viewership of the post.

Although, spamming prevention via email and other internet services such as social media and instant messaging is been implemented for privacy and security reasons, it plays a major role in reducing the generation of greenhouse gases as all these actions require the same resources as sending an email.

Proposed Methods for Mitigation of Carbon Foot Printing

Due to the liberty of information system usage, internet users cannot be stopped from exploring all features available to them. The proposed approach to this issue is a coordinated form of awareness creation as discussed below.

a. **Use of More Eco-Friendly Power Sources:** In the United States of America, technology companies have been instructed to use eco-friendly power sources such as solar and windmill to generate electricity to power and cool their servers. This is a big step towards reducing their carbon footprint as greenhouse gas generation will be eliminated from the area of power generation in running those large data centers. However, this law is yet to be implemented in developing countries like Nigeria, Ghana and most African Countries. Government officials and policy makers must be brought to the awareness of the implications of these diesel engines that are being used by telecommunication companies in powering their data and switching centers.

b. **User Awareness:** There are a number of online activities that may be classified as non-essential for internet users such as sending "Thank you" emails all the time and sending unnecessary broadcasts on social media and instant messenger applications. Tech companies running these platforms should be encouraged to enlighten their users on the environmental implications of unnecessary internet activities as they cumulatively have an effect in increasing their carbon foot print due to the emission of greenhouse gases as a result of the heat generated from these servers.

c. **Developer Awareness:** Developers have a major role to play in this issue by limiting certain user activities. For example, an application can limit the number of messages a user can send within a predefined time. Although, this technique is used to mitigate spamming, it can still be used to reduce carbon foot printing. Information system developers should be given the awareness about the effect of loading an information system with features of little importance to the overall functionality of the system. This will help them make informed decision when designing and developing a new system.

d. **Increase Email Auto response time:** When a user sends an email there should be a clause that gives the recipient the opportunity to use a longer response time as opposed to the normal instant reply. In doing so, if the recipient replies the sender within the waiting period, there will be no need for an auto reply. The goal is to send less emails.

Conclusion

The idea of green computing with respect to carbon foot printing has been overlooked because it's effects appear to be less fatal compared to the petroleum and automobile industries. However, research shows that it will be an issue of concern as more data is being generated per second and new information systems are being rolled out. This will bring about more power consumptions due to the need of more data centers. There is an urgent need to create awareness on eco-friendly techniques of using information systems to better reduce our carbon foot print.

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