

A REVIEW ON WASTE MANAGEMENT AGGREGATE - RUBBER WASTE

V K NITHIN¹

¹(Mechanical Engineering, Universal Engineering College, and Thrissur
Email: vknithmen@gmail.com)

Abstract:

For rubber waste, energy recovery and recycling are the two most widely used methods, but prevention measures have not yet been developed. Conventional recycling processes consist of breaking down various bridges and chains to a greater or lesser extent, which impairs the elastomeric properties of recycled materials. The purpose of this review is to look at rubber longevity strategies. We take a general approach consisting of investigating both the history of rubber use and waste management, and look for more recent, possibly kinetic chemicals for elastomer recycling or life cycle extension. We looked at more efficient use. These new formulations show the potential for tomorrow's industrial rubber. Disposal and recycling of currently used rubbery objects is a current problem. Today, the meaning of rubber has been extended to include any material with mechanical properties substantially similar to rubber, regardless of chemical composition. The new term elastomer also refers to all materials with rubber-like properties. Various techniques can be used to recycle rubber.

Keywords — : Recycling, Elastomeric properties, Waste management, Rubber waste.

I. INTRODUCTION

Recycling of plastics and rubber has received a great deal of attention for some time and is closely related to other current issues such as environmental protection, waste disposal, energy conservation and maintaining a favorable environmental balance payment in developed countries. increase. Polymers, commonly referred to as “plastics,” are the materials of the 21st century. They are used in all stages of our daily lives in a variety of applications, including automotive, construction, aerospace, and pharmaceuticals. From a materials science point of view, they are mainly, Historically, he is divided into

two main classes, thermoplastics and thermosets. On the one hand, thermoplastics are long, twisted polymer chains that diffuse at high temperatures through a phenomenon called reptation. Without considering potential degradation during the recycling process, thermoplastics are theoretically fully recyclable with a simple injection or molding process. On an industrial scale, this recyclability explains why thermoplastics currently account for about 90% of total polymer consumption [9].

Elastomers are a special class of thermoset materials that exhibit additional excellent properties such as elasticity and resilience. They are widely used in

industries where flexibility is required, such as gasket or gasket manufacturing, or noise reduction and damping materials. Elastomers are one of the most versatile technical materials. However, being thermoset in nature [1] poses a major recycling problem. Crosslinking is necessary to obtain good mechanical properties, but it also implies the presence of irreversible chemical bonds between polymer chains that allow reprocessing or recycling of the material. With scarcity and rising prices of natural resources and increasing environmental awareness, waste management has become a major issue in today's society. Finding efficient ways to recycle, reclaim, or simply extend the life cycle of elastomers is necessary and industrially relevant [5].

SCOPE OF THE WORK

The lifespan and recycling of rubbery objects in use today is a current issue and will be covered in the second part of this review after a brief introduction to what rubber is. So far, recycling of used [15] items has been limited due to the associated loss of mechanical properties. Another strategy relies on chemical modification to make materials recyclable. The aim is to give the elastomer the processability of a thermoplastic while maintaining high modulus and minimal loss of duroplastic properties. This poses a number of chemical and physical challenges outlined in Part 3 of the review. New types of elastomers have been developed and are already in industrial use. These so-called thermoplastic elastomers (TPEs) are crosslinked by phase separation and physical interactions, but are not completely heat or solvent

resistant. Dynamic covalent chemistry is now recognized as a better method for creating environmentally friendly elastomers. The design of dynamic rubbery networks with covalent physical and dynamic interactions will be the focus of the fourth and final part of this review.

II. WASTE MANAGEMENT TECHNIQUES

II.I. PHYSICAL TECHNIQUES

Physical techniques show how to use mechanical properties and mechanical processes to break the crosslinks of rubber. Microwaves, ultrasound, etc. are common techniques used in physical engineering. [3]

Advantages

Waste rubber tires have become a global problem due to their non-biodegradability, combustibility and combustibility. chemical composition. Burning releases toxic gases that pollute the air and are a health hazard. If these are stored in landfills for long periods of time, toxic substances can leach into the soil and contaminate groundwater. Landfilling these will inevitably lead to landfilling. [28]

II.II. LANDFILLING TECHNIQUES

A landfill, also known as landfill, landfill, landfill, landfill, landfill, or landfill, is a place for the disposal of waste. Landfills, the oldest and most prevalent form of waste disposal, systematically bury waste on a daily basis. Separation, processing, recycling, etc.

If not stable, the landfill may shake violently or the ground may liquefy during an earthquake. [5]



FIG.1 WASTE RUBBER LANDFILL

II.III. MICROWAVES

Microwave recovery is based on the breaking of cross-links supported by the heat generated inside the material. This technology was first developed by Goodyear Tires & Rubber in the late 1970s. This is probably his one of the most selective processes. By choosing the right amount of energy, mainly sulfur-sulfur bonds and carbon-sulfur bonds are broken, resulting in good tensile properties after revulcanization. However, main chain scission is inevitable.

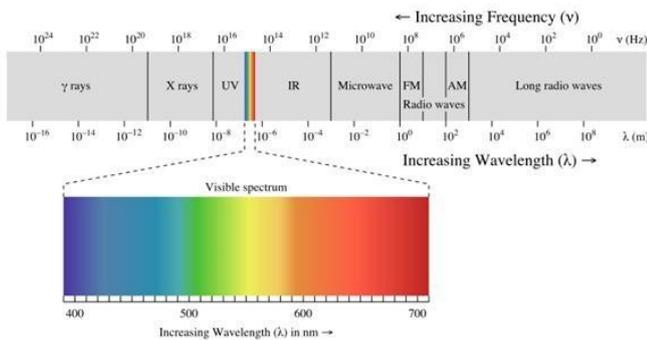


FIG.2 MICRO WAVE DISTRIBUTION

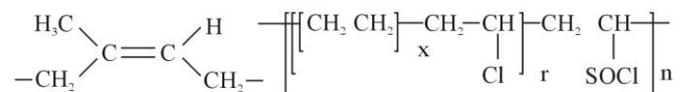
II.IV. ULTRASOUND TECHNIQUES

The application of specific ultrasonic amplitudes in combination with heat and pressure within the

extruder can effectively disrupt the network structure of crosslinked rubbers. According to the authors, the ultrasonic desulfurization process is very fast, on the order of 1 second, and breaks not only mono-, di-, and polysulfide bonds, but also carbon-carbon bonds in the main chain. The resulting material resembles the virgin material in terms of processing properties [9]12. After desulfurization, the rubber can be remixed with a crosslinker and compression molded to obtain a new crosslinked material. In the case of natural rubber, this technique allows us to obtain recycled material with the same elongation at break and 70% of the tensile strength of virgin material. According to the authors, this process maintains the crystallization ability of NR under stress.

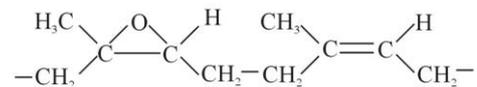
II.V. CHEMICAL TECHNIQUES

Rubber powder is usually chosen for chemical treatment, as the powder minimizes chemical diffusion problems within the network. Chemical methods are much more selective for breaking the crosslinks, which has a positive effect on the mechanical properties of the reclaimed material. However, the use of organic solvents is a major problem for industrial scale-up.[12]



Natural rubber, NR

Chlorosulfonated polyethylene, CSM



Epoxidized natural rubber, ENR

II.VI. PHYSICO-CHEMICAL TECHNIQUES

Most of the physical treatment methods mentioned above can be combined with the use of chemical

treatment agents to increase the efficiency of the process. Indeed, it is easy to combine a high temperature co-rotating twin-screw extruder process with the use of disulfide compounds to improve desulfurization of rubber. Microwaves are sometimes used in combination with inorganic salts and nitric acid. Finally, supercritical carbon dioxide can also significantly enhance the penetration of desulfurization reagents into the cured material, facilitating reactions even in the presence of carbon black or silica. In addition, CO₂ is an environmentally friendly alternative to organic solvents commonly used for chemical recovery and is non-toxic.

II.VII. MICROBIAL TECHNIQUES

Certain types of bacteria, chemoautotrophs, are capable of oxidizing sulfur. These microorganisms can be used to decompose sulfur-vulcanized rubber. The main limitation of this technique is that many microorganisms are sensitive to rubber additives, so it is necessary to find resistant bacteria or to remove additives by solvent soaking prior to desulfurization. GTR desulfurization has been performed using *Sphingomonas* sp and *Alicyclobacillus* sp., bacteria with sulfur-oxidizing properties extracted from coal mines. Microbial treatment offers the great advantage of being completely selective with respect to cross-linking and preserving backbone integrity.[12]

II.VIII. THERMAL TREATMENTS

Thermal processes involve thermal energy to break the crosslinks that form bonds. This process uses

thermal techniques such as hot pressing. Rubber is compressed by machines and rubber is molded into new products. Samples with the highest desulfurization quality, i.e. H. samples with more selective sulfur bond cleavage, were those treated at lower inlet temperatures. This was explained by the homogeneous self-heating effect of rubber, which contributes to the local increase in material temperature during the desulfurization process. Furthermore, it was found that the properties of the devulcanized rubber/raw rubber blend were not significantly affected by the addition of treated rubber. This result suggests that all natural rubber industry waste can be recycled into new competitive products with lower energy consumption. This represents a real contribution to industrial recycling and a visible improvement in the environment[12].

III. CHALLENGES

III.I. INDUSTRIAL CHALLENGES

Many dynamic chemical solutions have been developed for thermosets in general, some of which have been successfully used in elastomer materials, as discussed in the next section. However, industrial solutions have certain criteria that must be met.

Synthesis: Only chemically simple and cheap chemical syntheses are industrially relevant.

Use of Solvents: Organic solvents are expensive and hazardous chemicals and should be avoided whenever possible. The dynamic properties of rubber should ideally occur in the bulk state. [18]

Recycling conditions: chemical degradation of the polymer must of course be avoided.

III.II.CHEMICAL, PHYSICAL CHALLENGE

Dynamic rubber as an elastomer material. They can be crosslinked or polymerized by dynamic chemical reactions (that is, non-permanent chemical reactions) and undergo network rearrangements that provide recyclability or self-healing properties. Chemistry plays a key role in obtaining dynamic rubbers. The main strategies he can be classified into two types: modification of existing rubbery materials to allow dynamic cross-linking, or synthesis of new dynamic networks exhibiting rubber elasticity. Tweaking the chemistry can be an efficient means of tuning and tuning the physical properties of the final material. [18]

Dynamic, strong gels are a class of materials that share many similarities with elastomers. In fact, they consist of polymer chains that are crosslinked to form a network. Softness and the presence of solvents give good mobility.

It aids in the reorganization of polymer chains and networks, facilitating the creation of dynamic networks. Gels have some elastic properties, but their mechanical properties are usually far inferior to those of rubber. Rubber has a Young's modulus of about 1 MPa and has tensile properties of several MPa (10-20) and deformation of several hundred percent, while gels have a Young's modulus of about kPa and exhibit brittle behavior. Gum is a solvent-free material, so it is denser than gel. Introducing dynamic properties into rigid networks while maintaining good mechanical properties is a real challenge. Dynamically tuning the cross-linking at

elevated temperatures could be a solution. Temperature, like solvents, can increase chain mobility and reduce material viscosity. However, strong and stable mechanical properties should be maintained at the operating temperature. Excellent mechanical properties are related, among other things, to the presence of long polymer chains with many possible conformations. This poses another challenge in synthesizing rubber from dynamically bound small molecules. A functional but not liquid self-healing material can restore its original properties after cutting and rejoining without external intervention. This is very useful in extending the life of the material as it can be repaired continuously throughout its life cycle. In use, self-healing maintains mechanical properties by repairing microcracks. This process is highly dependent on the polymer structure and, in theory, true self-healing is achieved only if the properties of the repaired interface are the same as those of the bulk. Self-healing is possible when dynamic exchange occurs at room temperature. However, if the reorganization occurs without external stimulus, the material can creep and eventually behave like a liquid at room temperature. Therefore, a compromise must be found between self-healing and good mechanical properties. Leibler et al. took advantage of hydrogen bonding to obtain a fully self-healing rubber that exhibits recoverable elongation of up to several hundred percent and low creep under load. Characterization of dynamic behavior Spectroscopic or chromatographic studies can provide insight into

the exchange chemistry of dynamic rubbers. Moreover, physical and mechanical properties are very important for testing the actual recyclability or curability of materials. Some of the most important tests implemented are patch and weld, rework, repair test 80, or stress relief. The pull geometry is usually chosen for healing tests due to its simplicity. However, it has been shown to provide limited information and is highly dependent on the experimenter (due to the difficulty of precise repositioning of the cutting plane). Grande et al. implemented a fracture mechanics approach that has been shown to provide more reliable results.

II.III INCINERATION

Incineration of plastic waste alongside household waste is being actively viewed by plastic producers. They show the potential to release large amounts of heat that can be used to generate steam or electrical energy. In fact, many types of plastics have high calorific values. However, they are not ideal fuels, cannot be pumped, can melt during combustion, drip off grate bars, and continue combustion in ash disposal. will only become serious if the plastic content of the waste exceeds 10%. A soot-flaming rubber fire that needs a good afterburner. Additionally, incinerators can be damaged by near-explosive combustion of large volumes of highly flammable materials. This can occur when inexperienced crane operators fail to mix and deliver domestic and commercial waste. Various companies are developing specialized incinerators for plastics and rubber. Experimental results show that in the

presence of oxygen, gas formation involves two He reaction steps. The initial reaction temperature decreases, but the reaction area and reaction rate increase as the heating rate increases. The presence of oxygen in the carrier gas slightly accelerates the decomposition and speeds up the reaction once it begins. Reduces the activation energy of volatile products. Hydrocarbon emissions such as styrene, benzene, toluene, propanone, xylene, butane and 4-ethenylcyclohexene are the predominant species. In addition, the formation of hydrocarbon products also involves the process of recombination of free radicals and monomers.[3][1][2]

III.IV ENERGY RECOVERY

Waste rubber, which has a calorific value equal to or greater than that of coal, has potential as a substitute for fossil fuels. In fact, energy recovery is his second largest waste management method for rubber products, with 44% of end-of-life rubber in the EU being used for energy recovery in 2012 (a further 54% were recycled). The cement sector is a major user of scrap rubber for energy recovery, and more and more kilns are using scrap tires as an additional fuel. Burning rubber is associated with pungent black smoke and high levels of sulfur dioxide. The incinerator must therefore be capable of complete combustion at very high temperatures. To reduce costs, such furnaces are often combined with boilers that produce steam and power that can be used directly by nearby industrial facilities. Pyrolysis, unlike combustion, is the thermochemical decomposition of products by heat in the absence of

oxygen. This is a technology that uses heat to decompose and volatilize organic solids without burning them. For composite materials such as tires, the resulting products are hydrocarbons, coal (low carbon soot), and steel. The exact composition of hydrocarbons is temperature dependent. This is an attractive alternative to conventional pyrolysis as microwaves allow rapid heating of any absorbing material. However, due to its high complexity, pyrolysis is still considered an experimental method compared to the widespread incineration, and there are few examples of successfully operating pyrolysis plants worldwide. Rubber waste, especially worn car tires, poses a tremendous waste disposal problem because rubber is generally difficult to incinerate, dispose of, or recycle and the amount of waste involved is very high. A number of different processes have been tested for both destruction and recycling of rubber, including incineration, cooling and crushing, pyrolysis, recycling on road surfaces, and use on embankments.

IV. DISPOSAL OF WASTE FROM RUBBER INDUSTRY

Industrial waste can usually be separated and sorted. Consumer scrap is rarely perfectly identifiable. The value is highly dependent on the purity of the taxonomy and the presence or absence of contamination. This is why industrial scrap can find a market relatively easily. This is not the case with consumer scrap. We have a contract partner who collects thermoplastics, processes them and returns

them to the processor. They also make supplements to compensate for processing losses of additives. This type of operation is especially useful for materials such as P.V.C. Easily degraded during processing. Post-consumer waste, both plastic and rubber, has become a potentially emotional topic in recent years. What constitutes value as a recyclable material usually has little to do with the material. It is determined by the costs of collection, separation and decontamination. In general, plastic containers are lightweight and have a high volume-to-weight ratio. They can be packed, but shipping is still expensive. Separation into vessels of the same type is optically possible and often provides separation of different polymers as well, but becomes more difficult with closures made of different closures. For very thin-walled containers, the labels and adhesives used can also cause significant contamination. Tires are also a problem area. Not because it can't be recycled, but because it is reused and recovered for that purpose. The easiest way is to put a new layer of tread rubber on the outer circumference of the tire. Retreading is essentially the life of a new tire, so it is a very economical technique. In preparation for installing new tread rubber on a tire, it is "grinded" to remove some of the old tread. Gum powder is called crumb and is sold as a processing ingredient for use in small amounts in fresh mixes. Another use of old tires is in the manufacture of material called 'remanufacturing'. For "recovery", the entire tire is shredded and the rubber compound section is separated from the fabric and steel reinforcement.

The rubber powder is then treated with a combination of heat, mechanical work and chemicals. The resulting plasticized rubber crumbs are finally refined into slabs approximately 0.02 mm thick by passing through a very narrowly spaced two-roll mill. Layers of these spiders are wrapped around a drum until there are enough layers to cut into sheets about 3/4 inch thick. This material is also used to give new compounds specific properties or to produce cheaper compounds.

V. CONCLUSION & OBSERVATIONS

Due to the widespread use of these materials in everyday life, end-of-life rubber disposal has become one of the major environmental concerns. Recycling of rubber is made difficult by the inherently permanent thermosetting nature of elastomers. However, dynamic chemistry offers a variety of solutions for increasing upstream recyclability or material longevity. This chemistry has the potential to overcome various chemical and physical challenges of rubber waste treatment. All dynamic solutions have strengths and weaknesses. Dynamic rubber, like traditional rubber, is all about compromise. Thermoplastic elastomers are already widely used industrial materials. They represent a good compromise between the tensile properties of rubber and the full processability of thermoplastics. However, they also have drawbacks that prevent their use in more demanding applications. Restoration seems like a good option to avoid wasting rubber. However, this is a challenge

as self-healing must occur under operating conditions (temperature, humidity, etc.), but under exactly the same conditions the material must also exhibit stable mechanical and physical properties. . Vitrimer cross-linking is probably one of the best solutions to obtain a material with both very good rubber properties (elasticity, high tensile strength, solvent resistance, high cushioning properties, etc.) and complete recyclability. to industrial rubber. In fact, the base rubber is key to exploiting the excellent mechanical properties of elastomers, and Vitrimer chemistry is the only dynamic chemistry that combines recyclability with complete solvent resistance. Giving natural rubber vitrimeric properties remains a very interesting challenge. Separating polymer blends into different plastic materials is a viable possibility. However, with currently available techniques, the number of "errors" is still too high. Therefore, the material obtained cannot be placed on the market. Pyrolysis of plastics and rubbers is a relatively easy way to recover some of their potential energy, perhaps along with household waste. is not considered a completely satisfactory method.

REFERENCES

- [1]. Buekens, Recycling in Belgium, International Congress on the Recycling of Materials, Rotterdam, Xi-27 November (1974).
- [2]. P.-G. De Gennes, Scaling concepts in polymer physics, Cornell university press, 1979
- [3]. D. Montarnal, M. Capelot, F. Tournilhac and L. Leibler, Science, 2011, 334, 965-968
- [4]. L. R. G. Treloar, The physics of rubber elasticity, Oxford university press, 1975.
- [5]. B. L. Chan, D. J. Elliott, M. Holley and J. F. Smith, Journal of Polymer Science: Polymer Symposia, 1974, 48, 61-86.

- [6]. R. Ahmed, A. van de Klundert and I. Lardinois, RUBBER WASTE Options for Smallscale Resource Recovery Urban Solid Waste Series 3, 1996
- [7]. S. Ramarad, M. Khalid, C. Ratnam, A. L. Chuah and W. Rashmi, Progress in materials science, 2015, 72, 100-140.
- [8]. R. Tripathy, J. E. Morin, D. E. Williams, S. J. Eyles and R. J. Farris,
- [9]. S. B. Liang, D. P. Hu, C. Zhu and A. B. Yu, Chemical Engineering & Technology, 2002, 25, 401-405.
- [10]. M. Le Neindre and R. Nicolay, Polymer Chemistry, 2014, 5, 4601-4611.
- [11]. M. Sabzekar, M. P. Chenar, S. M. Mortazavi, M. Kariminejad, S. Asadi and G. Zohuri, Polymer Degradation and Stability, 2015, 118, 88-95.
- [12]. F. Sadaka, I. Campistron, A. Laguerre and J.-F. Pilard, Polymer Degradation and Stability, 2013, 98, 736-742
- [13]. P. Cordier, F. Tournilhac, C. Soulié-Ziakovic and L. Leibler, Nature, 2008, 451, 977- 980
- [14]. Y.-X. Lu, F. Tournilhac, L. Leibler and Z. Guan, Journal of the American Chemical Society, 2012, 134, 8424-8427
- [15]. M. AbdollahZadeh, C. Esteves, A. Catarina, S. Zwaag and S. J. Garcia, Journal of Polymer Science Part A: Polymer Chemistry, 2014, 52, 1953-1961.
- [16]. Y.-X. Lu and Z. Guan, Journal of the American Chemical Society, 2012, 134, 14226- 14231.
- [17]. W. Denissen, G. Rivero, R. Nicolaÿ, L. Leibler, J. M. Winne and F. E. Du Prez, Advanced Functional Materials, 2015, 25, 2451-2457.
- [18]. M. M. Obadia, B. P. Mudraboyina, A. Serghei, D. Montarnal and E. Drockenmuller, Journal of the American Chemical Society, 2015, 137, 6078-6083.
- [19]. J. G. Curro and P. Pincus, Macromolecules, 1983, 16, 559-562. 86. M. A. Rahman, L. Sartore, F. Bignotti and L. Di Landro, ACS Applied Materials & Interfaces, 2013, 5, 1494-1502.
- [20]. J. G. Drobný, Handbook of thermoplastic elastomers, Elsevier, 2nd edn., 2014
- [21]. Z. Wang, L. Yuan, N. M. Trenor, L. Vlaminc, S. Billiet, A. Sarkar, F. E. Du Prez, M. Stefik and C. Tang, Green Chemistry, 2015, 17, 3806-3818.
- [22]. Y. Coran and R. P. Patel, in Polypropylene Structure, blends and composites, ed. J. Karger-Kocsis, Springer Netherlands, 1995, ch. 6, pp. 162-201.
- [23]. J. G. Drobný, in Handbook of Thermoplastic Elastomers, William Andrew Publishing, Norwich, NY, 2007, ch. 9, pp. 215-234.
- [24]. K. A. Houton and A. J. Wilson, Polymer International, 2015, 64, 165-173.
- [25]. Y. Nakayama, K. Aihara, H. Yamanishi, H. Fukuoka, R. Tanaka, Z. Cai and T. Shiono, Journal of Polymer Science Part A: Polymer Chemistry, 2015, 53, 489-495.
- [26]. Y. Chen, A. M. Kushner, G. A. Williams and Z. Guan, Nature Chemistry, 2012, 4, 467-472.
- [27]. M. R. Tant, K. A. Mauritz and G. L. Wilkes, Ionomers: synthesis, structure, properties and applications, Springer Science & Business Media, 1997
- [28]. T. Xavier, J. Samuel and T. Kurian, International Journal of Polymeric Materials and Polymeric Biomaterials, 2003, 52, 251-264.
- [29]. J. Hellmann, C. Hilger and R. Stadler, Polymers for Advanced Technologies, 1994, 5, 763-774.