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Mechanical Properties of Rice Husk Reinforced Thermoplastic Waste/Virgin Resin Composite

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Abstract: *Rice husk is one of the major agricultural wastes produced as a by-product during the processing of rice. It has been a problem for rice farmers due to its poor rate of decomposition. It is difficult to digest by animals and has very low nutritional value and thus is not used as animal feeds. This rice husk and polypropylene wastes were used together with virgin Polypropylene resin in different proportions and produced rice husk fiber reinforced polypropylene composite. It was found that the tensile strength of the composite decreased with the incorporation rice husk fiber. Increase in both flexural strength and hardness was observed. It was also revealed from the result of water absorption test that the water absorption increased as the fiber loading increased.*

Key words: *Polypropylene, rice husk and waste.*

Introduction

Different types of material are required for many different areas of applications. In present days manufacturing demands high accuracy, good quality and high strength to minimum weight which the conventional materials do not offer. Polymers have substituted many of conventional materials, especially metals, in various applications due to their advantages over the conventional materials. They are used in many applications because they are easy to process, low cost and versatility. However, for some specific uses, some mechanical properties, such as strength and toughness of polymer materials are inadequate. In order to improve such properties various approaches have been developed. One of these approaches is production of composite. Composite material is a combination of at least two chemically distinct materials with a distinct interface separating the components. Composite is any material made of more than one component (Chand *et al.*, 2016). Composite is one of the most advanced and adaptable engineering materials. The properties of polymers are modified using fillers and fibers to produce composite in order to meet the desired requirements. Fiber-reinforced polymer composite have better specific properties compared to the conventional materials and find applications in diverse fields, ranging from appliances to spacecraft (Saheb and Jog 1999). Natural fiber-reinforced polymer composites have attracted more and more research interests owing to their potential as an alternative for synthetic fiber composites such as glass or carbon fiber composites (Bledzki and Gassan, 1999). Natural fiber offer many technical and ecological benefits as a reinforcement in composite production. Many types of natural fibers have been investigated for use in plastics composite. Some of these include; jute, straw, Flax, hemp, wood, sugarcane, bamboo, grass, kenaf, sisal, coir, rice husks, wheat, barley, oats, kapok, mulberry, banana fiber, raphia, pineapple leaf fiber, papyrus etc. and the matrix material used for reinforcing the fibers are classified as thermosets, thermoplastics and elastomers. Natural fibers have been used to reinforcing materials for over 2,000 years. The necessity for renewable fiber reinforced composites has not been as prevalent as now. Natural fibers are emerging as cost effective and apparently ecologically superior substitutes to glass fibers in composites. Natural fiber composites have many advantages such as availability, renewability of raw materials, low cost, light weight to high specific strength, and stiffness. Natural fiber thermoplastic composites are relatively new family of composite materials. In such composites, a natural fiber/filler (such as kenaf fiber, wood fiber, hemp, sisal etc.) is mixed with a thermoplastic (e.g., polyethylene, polypropylene, PVC etc.) to produce the composite. In the last few years, thermoplastics as well as thermoset based natural fiber composites (NFCs) have experienced a tremendous growth in the auto industry due to environmentally friendliness, renewability of these fiber, good sound abatement capability, and improved fuel efficiency resulted from the reduced weight of the components.

Today, plastics are almost completely derived from petrochemicals produced from fossil oil and gas. Around 4 % of annual petroleum production is converted directly into plastics from petrochemical feedstock (British Plastics Federation, 2008). As the manufacture of plastics also requires energy, its production is responsible for the consumption of a similar additional quantity of fossil fuels. However, it can also be argued that use of light-weight plastics can reduce usage of fossil fuels, for example in transport applications when plastics replace heavier conventional materials such as steel (Andrady and Neal 2009; Thompson *et al*. 2009). Approximately 50 % of plastics are used for single-use disposable applications, such as packaging, agricultural films and disposable consumer items, between 20 and 25% for long-term infrastructure such as pipes, cable coatings and structural materials, and the remainder for durable consumer applications with intermediate lifespan, such as in electronic goods, furniture, vehicles, etc. (Hopewell *et al*., 2009). Recycling of a wider range of post-consumer plastic packaging, together with waste plastics from consumer goods will enable improvement in recovery rates of plastic waste and its diversion from landfills. Recycling of waste plastics is an effective way to improve the environmental performance of the polymer industry.

Rice husk (RH) is one of the major agricultural wastes produced as a by-product during processing of rice. It has been a problem for rice farmers due to its poor rate of decomposition. It is difficult to digest by animals and has very low nutritional value and thus is not used as animal feeds. It is one of the most widely available agricultural wastes in many rice producing countries of the world (Kenechi *et al*., 2016). Marti-Ferrer *et al.*, (2006) reported that rice husk has lower lignin hemicelluloses and cellulose contents compared to wood hence it Flour can be processed at higher temperatures and this makes it attractive material in the manufacture of natural fiber reinforced polymer composites (Kenechi *et al*., 2016). Nwanonenyi and Obidegwu (2012) investigated the Mechanical Properties of Low Density Polyethylene/Rice-Husk Composite using Micro Mathematical Model Equations and reported that the mechanical properties of the composite indicate that it may be useful in some applications that require low strength, high stiffness and hardness Nwanonenyi and Ohanuzue, (2011) in his research conducted on the effect of Rice-Husk Filler loading on Some Mechanical Properties of Low Density Polyethylene found out that the tensile modulus and hardness increased with increase in filler loading but the tensile strength and percentage elongation decreased with increase in filler loading. In addition, it was also reported that other properties such as water absorption, specific gravity and flame retardant properties increased as filler loading increases. Dimzoski (2009) studied properties of rice-hull-filled polypropylene (PP) composites. Using the concept of linear elastic fracture mechanics, Introduction of rice hulls in the PP matrix resulted in a decreased stress at peak, together with increase of composites tensile modulus and modulus in flexure. Toro (2006) reported that the increase of the rice husk filler in the PP matrix composite decreases the stiffness, and in the presence of PP-g-MMI as compatibilizer in PP/rice-husk composite, the tensile modulus and water absorption of the composite were improved. Rosa *et al.,* (2009) studied on the Properties of Rice-Husk-Filled-Polypropylene composites with Maleic anhydride modified propylene as the coupling agent, it was verified that tensile strength decreased with filler loading. The presence of MAPP improved this property showing a strong dependence on the MAPP/RHF ratio Choi *et al.,* (2006) developed a new recycling method for rice husks and waste expanded polystyrene, with a view of using the styrene solution of waste expanded polystyrene as a binder for rice husk-plastic composites, their water absorption and expansion in thickness are decreased with increasing binder content and filler-binder ratio, since the composites formed have a high flexural strength and water resistance, their uses as building materials are expected. From the literature reviewed no work was done on the use of mixed polypropylene waste/virgin resin as reinforcement for natural fiber reinforced composite. Hence there is the need to produce and characterize such a composite.

Methodology

Materials/Equipment

Materials

- Rice husk fiber
- Polypropylene waste
- Polypropylene virgin resin

- Sodium hydroxide (NaOH) granules
- Distilled water
- Clorox disinfectant

Equipments

- Universal Testing Machine, (Model 3365, Instron 5KN Capacity)
- Carver-3851, pressure compression molding machine of 30tonn capacity
- Two roll mill
- An impact tester (Tinius Olsen, Model Impact 104. USA)
- Digital weighing balance
- Specimen mould
- Shredder

Methodology

Preparation of rice husk

Rice husk waste was collected from agricultural farm areas at zabarmari, Jere L.G.A., Nigeria and was dried so as to lower the moisture content. This was ground kept in cleaned container.

Preparation of polypropylene waste

PP waste was sourced from domestic plastic waste, shredded into palates and then immerse in diluted Clorox disinfectant solution (5%) for 30 min. this was followed by washing it with liquid detergent solution and then rinsed with water and dried.

Formulation and Production of the composite

The PP virgin resin, PP waste and the rice husk fiber formulations was done in such a way that the virgin PP resin was kept constant at 40wt% while proportion of the PP waste and the rice husk fiber were varied as follow; 50/10wt%, 40/20wt%, 30/30wt% 20/40wt%. Each formulation was subsequently blended using two roll mills, at 40 rpm processing speed and 190^{o}c. The blends were then used to make test samples by compression molding process. Sample plate of each formulation was produced and five test samples for each property under consideration were cut from the sample plates.

Tests

The mechanical properties tested include; tensile strength, flexural strength and hardness. Physical property test (i.e. Water absorption) was also carried out.

Results and discussions

The results of tensile strength tests conducted are presented in figure 1

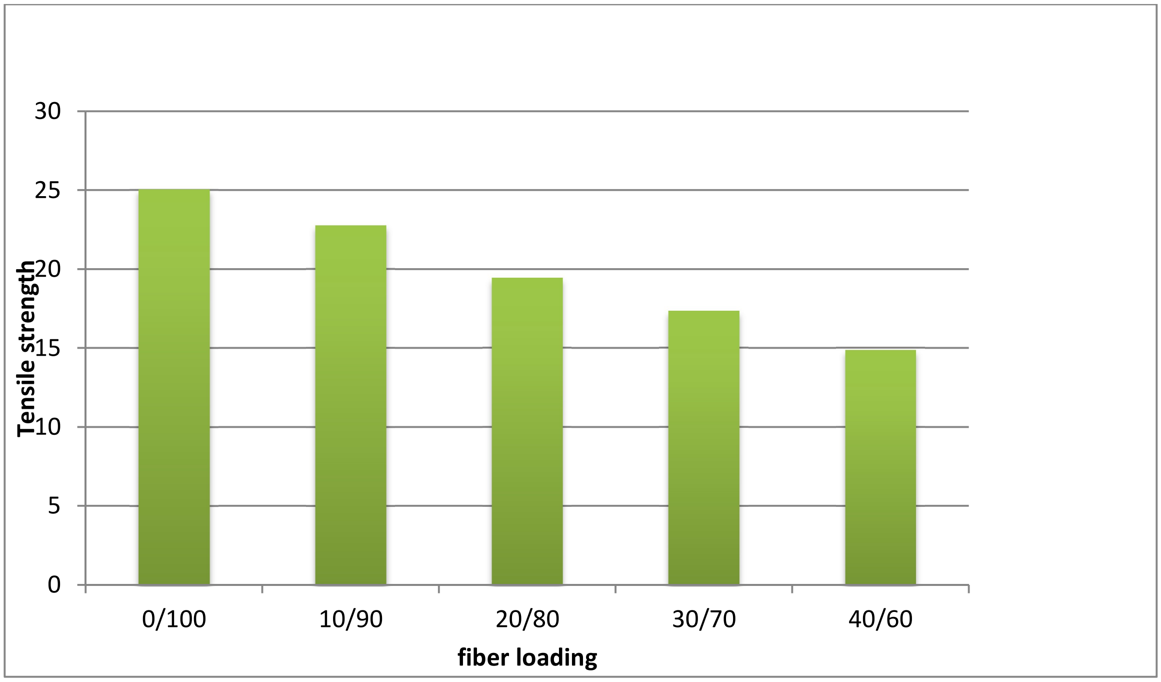

Figure1: Tensile strength of the composite at different fiber loadings

It can be seen the figure1that the tensile strength decreased with the addition of fiber this property continued to decrease up to 40 wt%; this may be due to the reduction in the extensibility by rigid particles and the formation of clusters of the PP matrix, which resulted in the increase of stress concentration zones and weakened the interfacial bonding strength of the sample (Ho, *et al*. 2015) and partly due to poor bonding between the propylene matrix and the fiber reinforcement.

The results of flexural strength of the composite

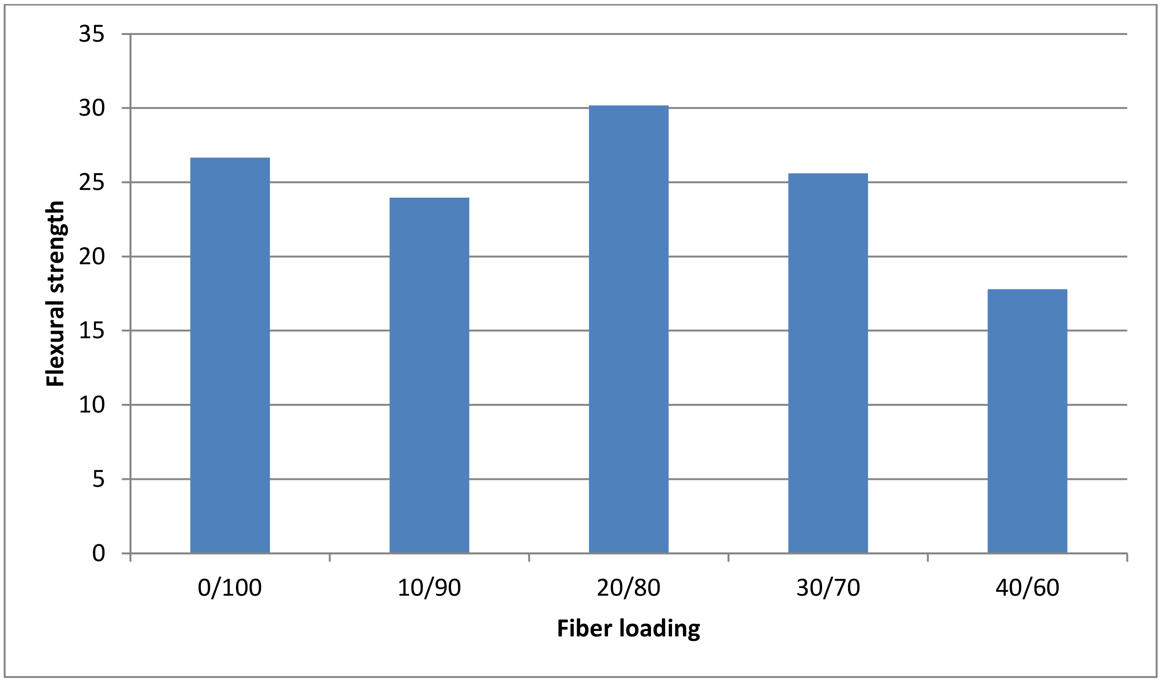

Fig. 2: Effect of varying fiber loading on Flexural strength of the composite

Figure 2 presents the flexural strength of the composite as function of fiber loading. At 10 wt. % fiber loading the flexural strength dropped but in subsequent loading increase in flexural strength was observed and began decrease thereafter. It is clear from above despite incorporation of the waste Polypropylene the fiber has influenced the flexural strength positively.

Table 2: ANOVA for flexural strength test

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	413.708	4	103.427	235.2753	1.64327E-16	2.866081402
Within Groups	8.792	20	0.4396			
Total	422.5	24				

It was confirmed from the Analysis of variance that variation of fiber loading has influence on the flexural strength of the composite as the p-value is far less than 0.05.

Vickers hardness test results of the composite

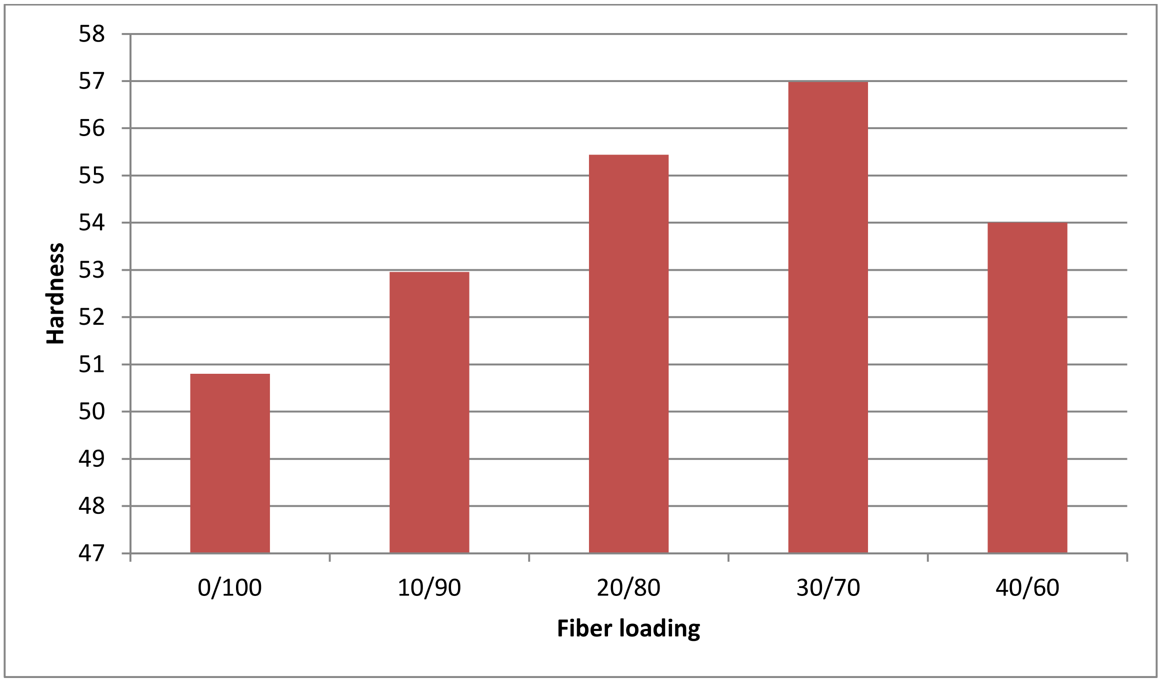

Fig. 3: Vickers hardness of the composite at different fiber loading

The Vickers hardness increased as the fiber loading increased. Maximum hardness was observed at 30 wt. % fiber loading but this property dropped thereafter.

Table 1: ANOVA table for Vickers hardness

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	111.3456	4	27.8364	24.15096	2.05E-07	2.866081
Within Groups	23.052	20	1.1526			
Total	134.3976	24				

The Anova table confirmed that fiber variation of loading has influence on hardness of the composite as the p-value is far less than 0.05.

Water absorption property test results

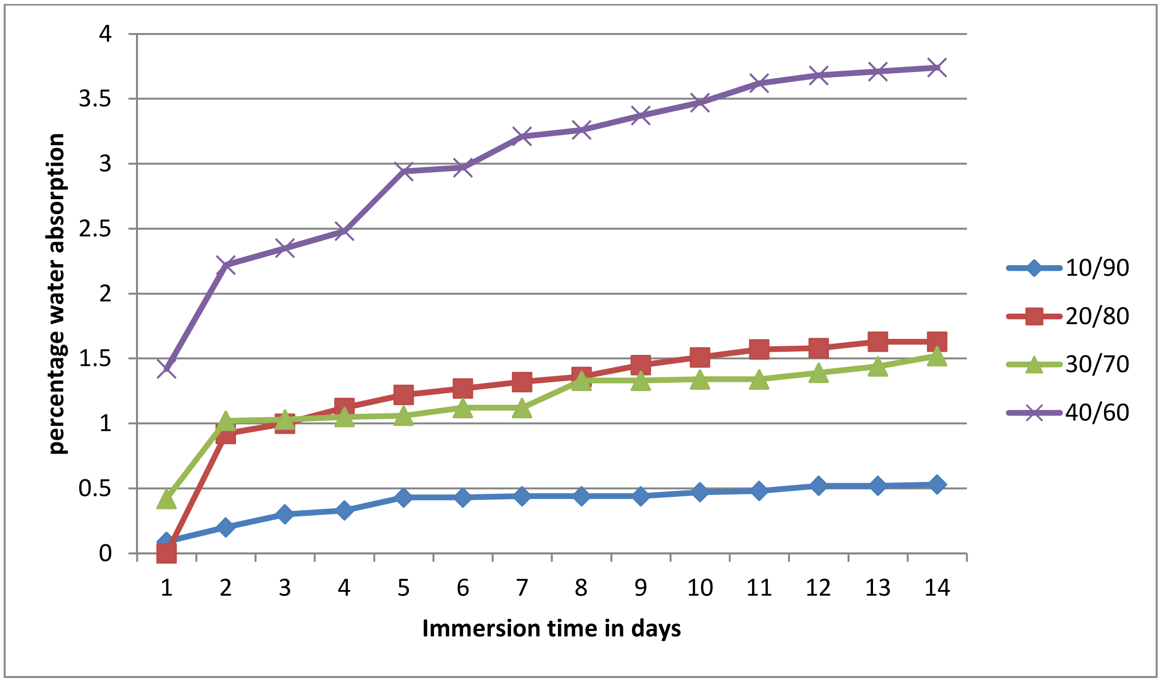

Fig. 4: water absorption property of the composite

Fig. 4 presents the water absorption of 10%, 20%, 30% and 40% of rice husk particles reinforced Polypropylene composites. It is clear from the figure that highest percentage of water absorption was at 40% rice husk fiber reinforced Polypropylene composite and the least was recorded at 10wt. % fiber loading. At lower fiber and shell particles loadings the quantity of the matrix is sufficient enough to encapsulate the fiber which by extension reduces water intake of the composite but as the percentage of fiber and the shell particles increases the matrix ability of encapsulation reduces, giving room for the composite to absorb more water

Conclusion

- Rice husk fiber reinforced polypropylene (virgin resin) and polypropylene waste composite has been produced and tested.
- The composite produced is not suitable to be used where tensile strength is major requirement because decline in this property was observed.
- Improved flexural strength and hardness were seen from the composite hence it can be used where these two properties are of interest.
- The composite water absorption was not much. It is also fiber loading and time dependant therefore, selection can be made from among the composites of different formulation, the one that best suit the intended purpose.

Andrady, A. L. and Neal, M. A., (2009) Applications and societal benefits of plastics, *philosophical Transaction of Royal Society* B, 1977–1984

Bledzki, A.K. and Gassan, J. (1999) Composites reinforced with cellulose based fibers. *Progress of Polymer Science*: 221-274.

British Plastics Federation, (2008), Oil consumption See http://www.bpf.co.uk/Oil_Consumption.aspx (20 October 2008)

Chand Badshah S. B. V. J., Arun, K., Eswaraiah B. and Krishna, M., (2015), Fabrication and mechanical properties of natural (coconut) & synthetic fibers (glass fibers) reinforced polymer composites material, *International Journal of Emerging Trends in Engineering Research*, 483 - 488

Dimzoski, B., Bogoeva-Gaceva, G., GentileAvella, , M., and Grozdanov A., (2009) "Polypropylene-based Eco-composites Filled with Agricultural Rice Hulls Waste". *Chem. Biochem. Eng.*, 225–230.

Jefferson Hopewell, Robert Dvorak and Edward Kosior, (2009) Plastics recycling: challenges and opportunities, philosophical Transaction of Royal Society B, 2115–2126

Kenechi Nwosu-Obieogu, Chiemenem Linus, Adekunle Kayode (2016) Utilization of Rice Husk as Reinforcement in Plastic Composites Fabrication- A Review, *American Journal of Materials Synthesis and Processing*, 32-36

Martí-Ferrer F, Vilaplana F, Ribes-Greus A, Benedito-Borrás A and Sanz-Box C. (2006) Flour rice husk as filler in block copolymer polypropylene: Effect of different coupling agents. *Journal of Applied Polymer Science*; 1823-1831

M. P. Ho, M.P., Lau,K.T., Wang, H. and Hui, D. (2015) Improvement on the properties of polylactic acid (PLA) using bamboo charcoal particles, *Composites part B: Engineering*, Vol. 81, 14-25

Nak-Woon Choi, Ippei Mori and Yoshiko Ohama (2006): Development of rice husks-plastics composites for building materials*; journal of waste management*, 189-194.

Nwanonenyi, S. C, and Obidegwu, M. U, (2012), "Analysis of Mechanical Properties of Low Density Polyethylene/Rice-Husk Composite using Micro Mathematical Model Equations" *IOSR Journal of Engineering, Vol. 2 (3) pp: 399-407.*

Nwanonenyi, S. C., and Ohanuzue, C. B., (2011) "Effect of Rice-Husk Filler on some mechanical and end use properties of low Density Polyethylene" *Journal of Technology and Education in Nigeria" Vol 16, No 1.*

Saheb D. Jog J.P. (1999), Natural fiber polymer composites: A review. *Adv. Polym. Technol.*, 18, 351–363

Rosa, S. M. L., Nachtigall S.M.A. and Ferreira, C. A. (2009) Thermal and Dynamic Mechanical Characteristics of Rice Husk Filled with Polypropylene Composites, *Macromolecular Research*, 8-13.

Thompson, R. C., Moore, C. J., vom Saal, F. S. & Swan, S.H. (2009) Plastics, the environment and human health: current consensus and future trends. Philosophy of Transaction Royal Society, 2153–2166

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