

# Making the Perfect Soccer Ball: A Review and Optimization of the Beautiful Game

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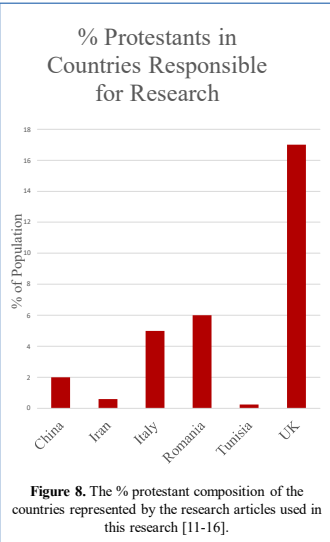
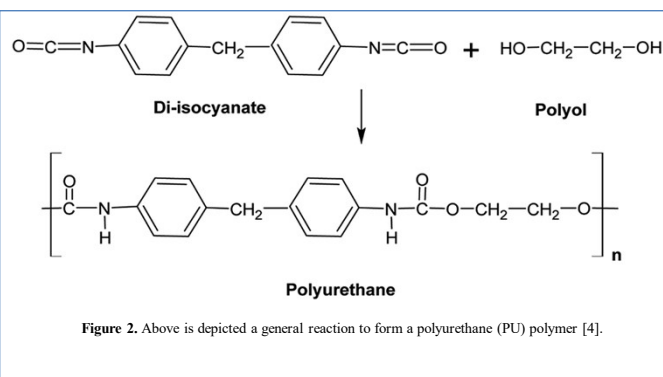
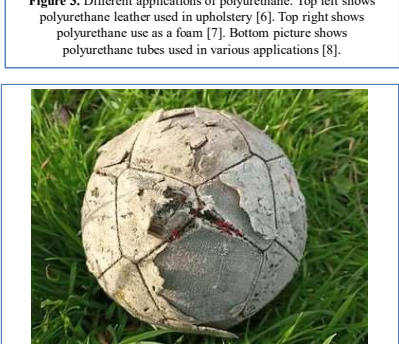
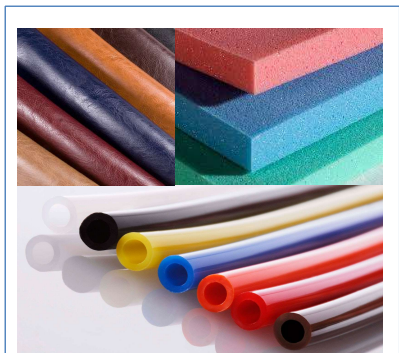
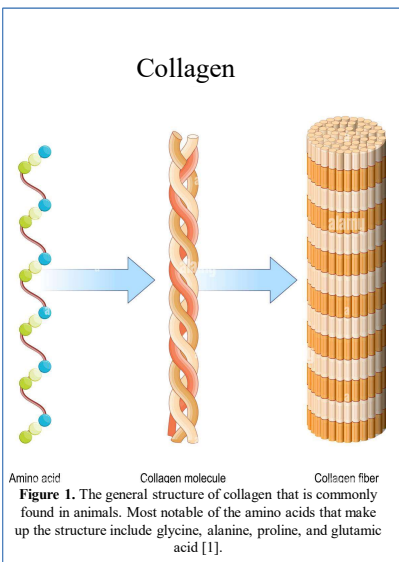
## Background

### History of the First Soccer Balls

The traditional ball used in the early 20th century was made from leather panels that were stitched together. Leather from cow hide is primarily made of collagen. This collagen protein is largely made up of the amino acids glycine, alanine, glutamic acid, and proline. Hydroxyproline is a rarely used amino acid that is used in considerable amounts in collagen [1]. This composition of amino acids forms a long fibrous protein that interacts with two other collagen peptide chains forming a trihelix arrangement (Figure 1). Another protein used in leather is α-keratin. The protein's composition is largely made of glutamic acid, aspartic acid, leucine, and serine. Keratin forms either an α-helical form or a β-sheet form. The keratin found in leather is found in a double helix from the α-keratin structure [2].

### Modern Adaption

The modern ball no longer uses leather due to the fact that the leather absorbs moisture over the course of use. Soccer ball manufacturers have switched to using polyurethane as a cover for many soccer balls [3]. Polyurethanes are generally synthesized by a diisocyanate and a polyol. These react together in a condensation reaction to yield a polymeric structure (Figure 2). By varying the type of polyol and diisocyanate, one can change the physical properties of the polymer (plasticity, rigidity, elasticity). This ability to modify the reagents used in the synthesis allows for the use of polyurethane in multiple applications. Figure 3 shows the multiple ways that polyurethane can be implemented in modern materials such as synthetic leather, foam mattress pads, and electrical insulators. Figure 4 shows the severe degradation of the outside cover of the soccer ball due to extended use and chemical degradation.



## Results and Conclusions

### Biblical Perspective

God has given man many natural polymers through his creation. In fact, man has made use of these polymers in the sport of soccer. Man has used the creative instinct given by God to make materials that can serve a specific purpose (Exodus 35:31-33.) Polymer chemistry can be used to further stewardship of the creation that God has given us (Psalm 24:1, 89:11, 95:5) [4].

### Gathering of Research Continued

After more intense literature search on polyurethane via Scifinder and Science-Direct, many journal articles, patents, and literature reviews were found (Figure 5). A select number of articles were found that were informative on the synthesis, examination, and degradation of polyurethane (Figure 6). The main article that has inspired this research is shown in Figure 7. This leading article has been cited in the references section [10].

### Evangelical Influence

Percent Protestants from leading research articles were obtained. The countries in question are as follows: China, Romania, Iran, Italy, Tunisia, and the United Kingdom. The percent of Protestants in these countries is shown in Figure 5 [11-16]. Notice relatively high percentages of protestants in Western developed countries while lowest are prominently Arab cultures.

### Market Prospects

Global soccer equipment sales were valued to \$12.13 billion [17]. Furthermore, soccer ball sales were estimated to be at \$4.04 billion. Of those sales Adidas generated around \$2 billion (Figure 4) [18].

## Future Work

The specific goal of this research is to formulate a higher quality soccer ball lining that is more durable than the current polymer linings on the market. Success will be measured when the polymer lining can be shown to be more durable than the current lining without negatively affecting performance. Attainable goals will be to reduce lacerations and polymer degradation. Other relevant goals would be to produce a polymer that does not have a high cost for the material. All of this research is projected to be done within one month.

Future work will be in the continuation of improving the outside layer of the soccer ball as new scientific breakthroughs and manufacturing processes become available.

## References and Acknowledgments

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## Research Question

How can the outside lining of the ball be improved against damage (i.e., UV damage, lacerations, and scuffing) while not negatively effecting the performance of the ball?

## Methods

### Gathering of Research

Data was received by entering in keywords to the SciFinder data base. Keywords such as “polyurethane” or “soccer balls and plastic polymers” were used. From these and other searches, 778 results showed up. The details of this search are shown in Figure 5. Ten research articles were shown to be helpful; topic breakdown is shown in Figure 6. More information is given in the results and overview section.

### Method of Testing

Implementation of this project would begin in testing the properties of the surface lining of common soccer balls. Basic tests examining the plasticity, tensile strength, toughness, and wear resistance will be performed. Research will be done to determine how the chemical composition of the polymer effects the performance of the material. Based on this research, three samples will be synthesized that can theoretically mimic or exceed expected properties of the outer lining. Physical properties testing of the samples will be performed. If a sample outperforms a commercially available option, this polymer will be marketed to soccer ball manufacturers.