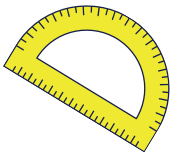
SOCCER BALL CHEMISTRY



This 5-minute activity aims to offer a practical insight into the daily tasks of a Materials Scientist. During the session, participants will analyze and assess the characteristics of various materials found in a soccer ball.

Materials

For 1 table with three stations operating continuously for three hours:

- Splash goggles
- Three size-two soccer balls
- Hand pump
- One box cutter or seam ripper
- 1-gallon distilled water
- Three small plastic cups
- 3-6 plastic pipets or droppers
- Three spill trays
- Paper towels
- Index cards and pens

Duration

Preparation: 30 min
Activity 5 min

Age Range

4-18 years

Questions & Content

What's inside a soccer ball?

How can a soccer ball be rigid and flexible?

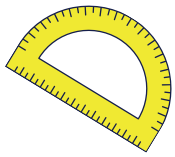
How do different materials interact with water?

- Different materials have different properties, such as how well they stretch and relax (elasticity) or how they interact with water (wettability).
- Think of a sponge. Absorption is how well it soaks up water. Wettability is how water interacts with the surface.
- If the surface of a material is strongly attracted to water, it's hydrophilic, and the water will spread out.
- If water is more attracted to itself than the surface of a material, the surface is hydrophobic, and the water will bead up.

Group Size

- 3 participants (trays per station), one facilitator per station
- 3 stations fit along a 6-foot-long table, serving up to 60 people/hour.

HOW DOES THIS WORK?



Elasticity in Soccer Balls

The elasticity of a soccer ball is crucial for its performance. Elasticity refers to a material's ability to stretch and return to its original shape. In the case of a soccer ball, the interior bladder, typically made of rubber, is responsible for this property. Rubber is a polymer, a long chain of repeating molecular units. These chains are coiled and tangled; when the bladder is inflated, they uncoil and stretch. Once the stress is removed (when the ball is not kicked), the polymer chains return to their original coiled state, giving the ball its bouncy characteristics. This elastic property allows the soccer ball to absorb the energy from a player's kick and then release it, propelling it through the air. The ability to repeatedly inflate and deflate the bladder without losing shape makes a soccer ball practical and durable for continuous play.

Hydrophobicity of Soccer Balls

The hydrophobicity of a soccer ball's exterior is another essential feature. Hydrophobicity means "water-fearing" in this context; it refers to the ball's ability to repel water. The outer layer of a soccer ball is often made from materials like polyurethane or PVC (vinyl plastic), which are polymers but have a structure that does not interact favorably with water. The molecular composition of these materials causes water to bead up and roll off the surface rather than soak in. This is advantageous for play in wet conditions, as it prevents the ball from waterlogging, making it heavier and more challenging. The hydrophobic nature of the ball's surface ensures that it remains light and easy to handle, even in the rain, contributing to a consistent playing experience.

Polymer Networks

The polymers in soccer balls are not just individual chains but part of a network. The polymer chains in the rubber bladder are cross-linked, which means they are bonded at various points. Cross-linking helps the material maintain its integrity and elasticity under the stress of being kicked. The exterior materials are also part of a polymer network, with the vinyl plastic providing the hydrophobic surface, a foam layer for cushioning, and a fabric layer for additional strength and structure. These layers work together to create a composite material that optimizes the ball's performance by combining elasticity with hydrophobicity, ensuring the ball is both responsive and resistant to the elements.

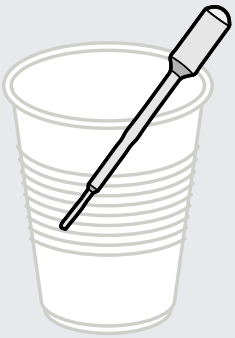
This activity was designed by scientists at the **Center for Molecularly Optimized Networks (MONET)**: Drs. Haley Beech (MIT), Vanessa Rosa (Duke), and Rebekka Klausen (Johns Hopkins). Edited by the Patti Galvan of the **American Chemical Society**.

PREPARATION (PART 1)

1. Each station will need three uninflated, size-two soccer balls. One will remain intact, one will be cut open to show the interior air bladder, and a third will be thoroughly deconstructed:
    a. **Ball 1**: do not cut. Use a hand pump to inflate.
    b. **Ball 2**:
        i. Using a box cutter or other sharp tool, cut the second soccer ball along the seam to puncture the ball.
        ii. Once there is a hole, you can switch to scissors. Cutting along the seams, cut out outer layer pieces without damaging the interior bladder.
        iii. Reach into the soccer ball and remove the intact bladder.
        iv. Use a hand pump to inflate only the air bladder.
    c. **Ball 3**:
        i. Using a box cutter or other sharp tool, cut the third soccer ball along the seam to puncture the ball.
        ii. Once there is a hole, you can switch to scissors. Cutting along the seams, cut out the outer layer pieces without damaging the interior bladder.
        iii. Save the pieces of the black and white exterior layer for participants to touch and stretch.
        iv. Peel 2-3 of the outer pieces apart to expose the three layers, which are composed of vinyl plastic (shiny outside of outer layer), foam (middle of outer layer), and fabric (inside of outer layer)
        v. Reach into the soccer ball and remove the bladder. Cut into rectangular strips (ca. 1-2 cm x 5 cm) for participants to touch and stretch.
2. For each station, have three plastic cups of water, each equipped with 2-3 plastic pipettes.

PREPARATION (PART 2)

1. Display **Ball 1** (intact and inflated), the air bladder from **Ball 2** (inflated), and the 2-3 pieces from the exterior layer of **Ball 3** that have been peeled apart to show the three layers.
2. Arrange 3 spill trays.
3. On each tray, place one piece from the exterior layer of ball 3 and one strip of the air bladder of ball 3.
4. Place one plastic cup and fill partway with water. Add two droppers or plastic pipettes.
5. Have a stack of index cards ready to hand out to the students.



Water cup & dropper

Piece from air bladder.

Piece from exterior layer.

Index cards ready to be handed out.

HYPOTHESIZE & INTRODUCE

Getting Started	Ask Participants	Details
Somewhat away from the tables, hand out an index card and pen to each participant. Display the fully intact soccer ball.	“Draw or write what you think is inside a soccer ball on your index card.”	• Accept the index cards and pens and guide students to a tray.
Introduce the activity.		• Tell participants that they will learn about the components of a soccer ball. • Show participants the inflated interior air bladder and the cut-up exterior layer pieces

STRETCH & OBSERVE

Details	Engaging Questions
Tell participants that stretching a material is called a **tensile test**. The ability of the air bladder to return to its original form after being filled with air is called **elasticity**. **Direct participants to:** • Stretch the exterior layer (it will be stiff). • Stretch the strip cut from the air bladder (it will be elastic). • Tell participants we need the inside to be elastic so we can fill and refill it with air so the ball bounces.	What makes a soccer ball bouncy? Can you predict how each layer of the soccer ball might respond to stretching? What do you notice about how the different pieces respond to pulling?

WET & OBSERVE

Details	Engaging Questions
Define **wettability** and **absorption**. *Absorption* is how well something soaks up water. *Wettability* is how water interacts with a surface. **Direct participants to:** • Add 1-2 drops of water to the shiny outside of the exterior layer. Make an observation (does water flatten out or bead up?) • Add 1-2 drops of water to the other side of the piece. Make an observation (does water flatten out or bead up?)	If it's raining during your game, do you want your ball to absorb the water or repel it? (repel!) Can you predict how each layer of the soccer ball interacts with water? What do you notice about how the different sides of the exterior layer interact with water?

CONNECT TO MATERIALS SCIENCE

Details	Engaging Questions
Explain that everything around us is made of different materials. **Materials science** is studying the different properties of materials (like *elasticity* or *wettability*). • We want a soccer ball to bounce! • This means we need an elastic component that can expand with air. The interior layer is made of rubber. • We also want the outside of the ball to repel water so it doesn't soak up water and get heavy if it rains during a game. The exterior layer is made of a hydrophobic vinyl plastic.	Can you think of other materials and objects that are elastic? Can you think of other materials and objects that hydrophobic or hydrophilic? What is the silliest thing you could make a soccer ball out of?