How Does an Orange Peel Pop a Balloon? Chemistry, of Course!

Tom Kuntzleman, Tori Talaski and Charles Schaerer

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The juice from an orange peel causes a balloon to pop. When I first saw this effect I immediately thought to myself, "what is the chemistry involved in this experiment?" After quickly searching the web, I found several claims that a compound in orange peels called limonene *(Figure 1)* is responsible for this effect. Limonene is a hydrocarbon, which means that molecules of limonene are composed of only carbon and hydrogen atoms. Limonene is responsible for the wonderful smell of oranges, and it is a liquid at room temperature.

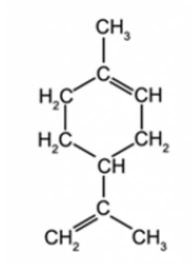

***Figure 1** - Chemical structure of limonene*

Because limonene is a hydrocarbon and hydrocarbons are non-polar molecule, one would expect limonene to be non-polar.

So what does all this chemical information have to do with balloons popping when squirted with orange peel juice? Well, balloons are made primarily of rubber. Like limonene, rubber is a hydrocarbon *(Figure 2),* so it's non-polar as well. It is well known by chemists that non-polar substances dissolve well in other non-polar substances. Therefore, when the limonene oil contacts the surface of a balloon, some of the rubber balloon dissolves in the limonene. This weakens the balloon, causing it to pop.

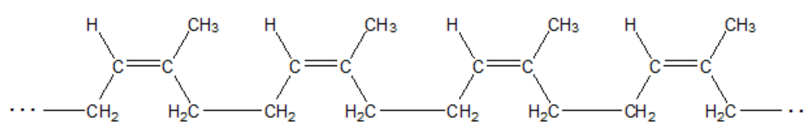

***Figure 2** - Chemical structure of rubber (chemical name: cis-poly isoprene). The pattern of atoms seen here is repeated hundreds of times over to make a **very** long molecule called a polymer.*

We wanted to test this claim that limonene oil is responsible for balloons popping. So we extracted some limonene oil from orange peels using a procedure published in the *Journal of Chemical Education*.[1] Sure enough, the extracted limonene caused our balloons to pop. Check out the videos of our tests in our original post at ChemEd X. You can find it using the URL https://bit.ly/2yUruSx or by searching **limonene**.

Interestingly, we observed that not all balloons pop when squirted with an orange peel. Of course, we asked "why". It has to do with chemistry, of course! The cis-poly isoprene molecules in rubber are very long molecules called polymers (see Figure 2 again). In natural rubber, these long molecular strands can readily separate from one another. Because of this molecular property, it is easy to get rubber to break into pieces or to dissolve in various solvents. This property of rubber can be changed through a process called vulcanization. During vulcanization, rubber is treated with sulfur. Vulcanization causes polymer strands to become connected by sulfur atoms (Figure 3) in what is called a cross-link. While the chemistry involved is more complex than indicated in the figure, the effect of vulcanization on rubber makes it very difficult for polymer molecules to separate from one another. Because of this, vulcanized rubber is tougher to break apart and more difficult to dissolve than normal rubber.

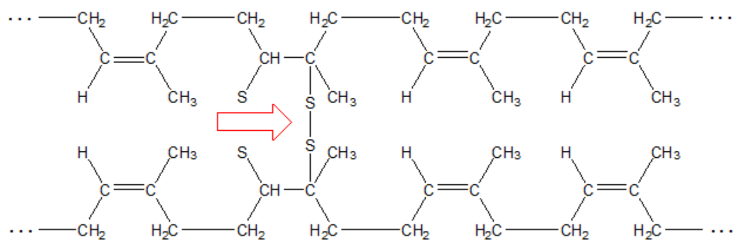

Figure 3 - *Simplified structure of cross-linked rubber. The red arrow identifies a cross-link between two polymer strands.*

Now that you know a bit about the chemistry of balloons, I think you might be able guess which balloons pop when squirted with the juice from an orange peel, and which balloons do not. Most balloons are made of vulcanized rubber[2], presumably to keep them from breaking easily when stretched. When a balloon made of vulcanized rubber is squirted with limonene or an orange peel, it doesn't break. Water balloons are not made of vulcanized rubber[2], because people generally want these balloons to be somewhat breakable. Because of this difference in its chemistry, a water balloon pops when squirted with limonene or orange peel juice!

We were interested to learn what types of easy-to-find, non-polar liquids can be used to cause balloons to pop. You can watch the second video included in our ChemEd X blog post to see what other liquids we tested (use https://bit.ly/2yUruSx or type **limonene** into the search box at www.chemedx.org).

Editors' Note: Laura Wang has expanded this work by creating a "QFT Task Student Handout", a "Balloon Lab Design Proposal" as well as a rubric (for the audience and the teacher) for the group presentation she assigns her students.[3]

References

1 - **Fitting It All In: Adapting a Green Chemistry Extraction Experiment for Inclusion in an Undergraduate Analytical Laboratory**, *Heather L. Buckley, Annelise R. Beck, Martin J. Mulvihill, and Michelle C. Douskey, Journal of Chemical Education*, **2013** 90 *(6), 771-774.*

2 - Evidence for these claims was gained by taking infrared (IR) spectra of balloons. Peaks were consistently observed at 670cm^{-1} (indicative of a C-S bond and therefore vulcanization) and 1010 cm^{-1} in the IR spectra of pop-resistant balloons. However, both of these peaks were consistently absent in the IR spectra of balloons that pop when treated with non-polar compounds.

3 - **Mini-Project Sequence: Orange Peels and Polarity –** *Laura Wang*
https://www.chemedx.org/blog/mini-project-sequence-orange-peels-and-polarity