Diet Coke and Mentos: What is really behind this physical reaction?

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The Diet Coke and Mentos reaction is a fun demonstration in chemistry and physics classes of many important concepts in thermodynamics, fluid dynamics, surface science, and the physics of explosions. The reaction has been performed numerous times on television and the Internet, but has not been systematically studied. We report on an experimental study of the Diet Coke and Mentos reaction, and consider many aspects of the reaction, including the ingredients in the candy and soda, the roughness of the candy, the temperature of the soda, and the duration of the reaction.

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I. INTRODUCTION

The popular Diet Coke and Mentos reaction occurs when new Mentos are dropped into a fresh bottle of Diet Coke and results in a jet of Diet Coke spray shooting out of the mouth of the bottle. Depending upon the number of Mentos dropped into the bottle, the spray height can vary between a few inches and tens of feet. The Diet Coke and Mentos reaction was the subject of a 2006 Mythbusters episode[1] and first shown in 1999 on the David Letterman Show, and has become a popular in-class physics and chemistry demonstration from elementary school to college level classes. A search on Google for "Diet Coke and Mentos" will return millions of hits, and YouTube has many home videos of this reaction. The Mythbusters team did a wonderful job of identifying the basic ingredients in this reaction. They cited the gum arabic and gelatin in the Mentos, and the caffeine, potassium benzoate, and aspartame in Diet Coke as the main contributors to the explosive reaction. They also hypothesized that the rough surface of the Mentos can help break the strong polar attraction that water molecules have for each other by providing growth sites for the carbon dioxide, agreeing with scientists such as Lee Marek and Steve Spangler.[2] Although they identified the prime ingredients, they did not sufficiently explain why those ingredients affect the explosion, nor did they provide direct proof of the roughness of the Mentos—a tall order for an hour-long television program.

The Diet Coke and Mentos reaction is a popular experiment or demonstration in part because it inspires students to wonder, and inquiry-driven labs and active-learning demonstrations on this reaction have been implemented.[3] I recently led a large group of undergraduate physics students in a cooperative research project to answer some of the debate on this reaction. This study began as a project for physics majors enrolled in a sophomore level physics lab course. The students designed the experiment, did almost all of the data acquisition, and disseminated their results in a poster session at our spring Research and Creative Endeavors Day at Appalachian State University.

II. EXPERIMENTAL PROCEDURE

We examined the reaction between Diet Coke and samples of Mint Mentos, Fruit Mentos, a mixture of Dawn Dishwashing detergent and water, playground sand, table salt, rock salt, Wint-o-Green Lifesavers, a mixture of baking soda and water, liquid gum arabic, and molecular sieve beads (typically found in sorption pumps). We also examined the reaction between Mint Mentos and Diet Coke, Caffeine Free Diet Coke, Coca-Cola Classic, Caffeine Free Coca-Cola Classic, seltzer water, seltzer water with potassium benzoate added, seltzer water with aspartame added, tonic water, and diet tonic water. All of the samples were at room temperature unless otherwise indicated.

We constructed a bottle stand (roughly 10° off vertical) to prevent the bottles from tipping over and the liquid from falling back into the bottle. To maintain consistency we also constructed a tube to fit over the mouth of the bottle and a delivery mechanism for the solid materials. The liquid samples, including the gum arabic, the baking soda–water mixture, and the Dawn–water mixture, were administered by injection using a 10 ml syringe with an 18-gauge needle. The seltzer water and tonic water trials were 1 l bottles with 16 g of Mint Mentos added; all other trials were 30 g of solid material added to a 2 l bottle of liquid. The intensity of the reaction was determined by measuring the mass of the bottle using a double pan balance before and after the reaction to determine the mass lost in the reaction and by measuring the horizontal distance traveled by the soda's spray. To ensure accurate distance measurements and to extract other useful information, a video was made of the reactions, and marker flags were placed every half foot on the level ground, up to a distance of 25 ft away from the bottle stand. For the Mint Mentos and baking soda trials, the pH of the Diet Coke before and after the reaction was measured by a pH meter with a two point calibration.

Sample morphology was determined by imaging the samples in an environmental scanning electron microscope (SEM).[4] The uncoated samples were imaged in low vacuum mode. Quantitative surface roughness measurements were made with a Digital Instruments contact mode atomic force microscope (AFM) with Nanoscope III control electronics and a J type scanner with a 24 μm z range. For each of the samples a $(10\ \mu\text{m})^2$ image was acquired, and the root-mean-square (rms) roughness in the image was reported. This size image was chosen for comparison between samples because the samples imaged were quite rough and had significant curvature, and images larger than 100 square μm often resulted in a z range larger than 24 μm.

For the temperature dependent trials one of the Diet Coke 2 l bottles was refrigerated for several hours prior to the experiment. The other bottles were heated in a water bath on a hot plate for approximately 10–20 min. Prior to heating, the bottle was opened to release some of the internal pres-

Table I. Average mass lost during the reaction. The uncertainty is approximately 10%.

Soda Used (2 l bottles)	Sample	Mass lost (g)
Diet Coke	Fruit Mentos	1440
Diet Coke	Wint-o-Green Lifesavers	1430
Diet Coke	Mint Mentos	1410
Caffeine free Diet Coke	Mint Mentos	1400
Coke Classic	Mint Mentos	1340
Caffeine free Coke Classic	Mint Mentos	1320
Diet Coke	Molecular sieve beads	1290
Diet Coke	Baking soda-water mixture	1210
Diet Coke	Rock salt	1170
Diet Coke	Playground sand	1140
Diet Coke	Cake Mates	1100
Diet Coke	Dawn-water mixture	1020
Diet Coke	Table salt	920
Diet Coke	Crushed mint Mentos	780
Diet Coke	Liquid gum arabic	100

sure, and then closed again. This procedure prevented the explosion of the bottle during heating, but the early release of some of the carbon dioxide gas may have caused these reactions to be less explosive than the cold or room temperature trials.

III. RESULTS AND DISCUSSION

The average amount of mass lost for the various combinations of soda and samples is given in Table I. The average distance traveled by the soda's spray during the explosion is given in Table II. The results in Table II are comparable to results from previous studies.[3] Two to four trials were done for each sample-soda combination. All of the Coca-Cola products had the same expiration date, so the level of carbonation in each 2 l bottle should be similar. The seltzer and tonic water trials had the same expiration date and were manufactured by the same company. The seltzer and tonic water were not Coca-Cola products, and it was not possible to find seltzer and tonic water with the same expiration date as the Coke products. Because the level of carbonation in these products might be different from the Coke products, the seltzer and tonic water results should be considered independently from the Coca-Cola product trials. The results for the trials with varying temperature are given in Table III. The measured contact angles and minimum works for bubble formation are given in Table IV. The AFM rms roughness measurements are given in Table V. The SEM images of some of the samples are shown in Figs. 1–3, contact angle images are shown in Fig. 4, and some of the AFM images are shown in Figs. 5 and 6.

Table II. Average horizontal distance traveled by the spray during the reaction. The uncertainties are approximately 10%.

Soda used (2 l bottles)	Sample	Distance traveled by spray (ft)
Diet Coke	Fruit Mentos	17.8
Caffeine Free Diet Coke	Mint Mentos	16.3
Caffeine Free Diet Coke	Baking soda-water mixture	15.5
Diet Coke	Mint Mentos	15.3
Caffeine free Coke Classic	Mint Mentos	12.3
Coke Classic	Mint Mentos	11.6
Diet Coke	Dawn-water mixture	10.5
Diet Coke	Wint-o-green Lifesavers	7.0
Diet Coke	Rock salt	6.3
Diet Coke	Playground sand	5.5
Diet Coke	Table salt	5.5
Diet Coke	Cake Mates	4.3
Diet Coke	Molecular sieve beads	2.5
Diet Coke	Crushed Mint Mentos	1.0
Diet Coke	Liquid gum arabic	<0.5

Table III. Temperature of a 2 l bottle of Diet Coke and mass lost during the reaction when 30 g of Mint Mentos is added to the Diet Coke. Only one trial was performed for each temperature.

Temperature (°C)	Mass lost (g)
47	1450
38	1350
6	1280

The *p*H of the diet Coke prior to the reaction was 3.0, and the *p*H of the diet Coke after the mint Mentos reaction was also 3.0. The lack of change in the *p*H supports the conclusion that the Mint Mentos–Diet Coke reaction is not an acid-base reaction. This conclusion is also supported by the ingredients in the Mentos, none of which are basic: sugar, glucose syrup, hydrogenated coconut oil, gelatin, dextrin, natural flavor, corn starch, and gum arabic. The classic baking soda and vinegar acid-base reaction produces unstable carbonic acid that rapidly decomposes into water and carbon dioxide, which escapes as a gas. For the Mentos–Diet Coke reaction, the carbonic acid and carbon dioxide are not products of a chemical reaction but are already present in the Diet Coke, whose equilibrium is disturbed by the addition of the Mentos. An impressive acid-base reaction can be generated by adding baking soda to Diet Coke. The *p*H of the Diet Coke after the baking soda reaction was 6.1, indicating that much of the acid present in the Diet Coke was neutralized by the reaction.

Contact angle measurements were made by placing small drops of the liquid solutions on a flat polycarbonate surface, photographing the drops, and measuring the contact angles

Table IV. Contact angles of various solutions on polycarbonate and the ratio of the minimum work required to form a critical bubble in the sample over the minimum work required to form a critical bubble in deionized H_2O.

Sample	Contact angle in degrees (uncertainty of ±3°)	$\frac{W_{\text{sample}}}{W_{\text{deionized water}}}$
Deionized H_2O	85	1
Deionized H_2O-sugar solution	80	0.74
Deionized H_2O-aspartame solution	77	0.67
Deionized H_2O-potassium benzoate solution	75	0.60
Diet Coke	75	0.62
Caffeine free diet Coke	78	0.69

Table V. The rms roughness of a 100 μm^2 image acquired in the AFM.

Sample	Root-mean-square roughness (nm)
Wint-o-Green Lifesavers	2630
Fruit Mentos	443
Mint Mentos	442
Rock salt	174

from the photographs (see Fig. 4). We used the measured contact angle to calculate the minimum work required to form a critical bubble[5] by the relation:

$$W = \frac{16\pi\gamma_{LV}^3}{(P' - P)} f(\theta), \tag{1}$$

where γ_{LV} is the liquid-vapor surface tension, $P' - P$ is the pressure difference across the interface, θ is the contact angle, and the function $f(\theta)$ is given by

$$f(\theta) = \frac{(1 - \cos\,\theta)^2(2 + \cos\,\theta)}{4}. \tag{2}$$

To compare two systems, we calculate a ratio of the works required for bubble formation:

$$\frac{W_2}{W_1} = \left(\frac{\gamma_{LV,2}}{\gamma_{LV,1}}\right)^3 \frac{f(\theta_2)}{f(\theta_1)}. \tag{3}$$

We used this technique to compare the work required for formation of a bubble in deionized water to other liquids, as summarized in Table IV. In Table IV we assumed that γ_{LV} was reduced by 5% for the second system compared to the deionized water (system 1). Compare the contact angle results in Table V for pure water (θ=85°), sugar water (θ=80°), and aspartame dissolved in water (θ=77°). The work required to form a bubble in sugar water and aspartame is 74% and 67%, respectively, of the work required to form a bubble in pure water. These calculations are approximate, but are consistent with our results reported in Tables I and II.

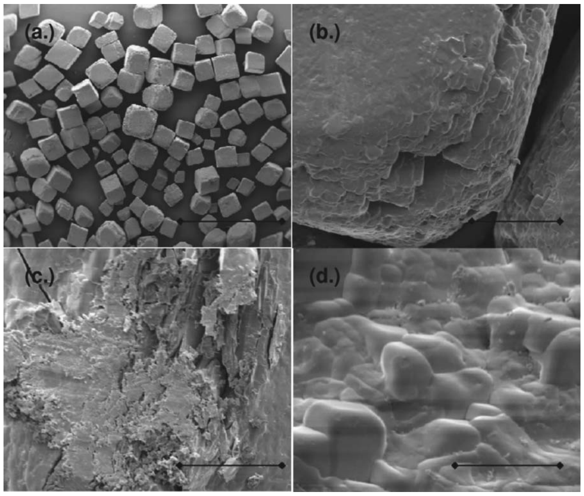

Fig. 1. SEM images of table salt, acquired with a beam energy of 5.0 kV and a spot size of 5 nm. The scale bars represent the following lengths: (a) 2.0 mm; (b) 100 μm, (c) 50 μm, and (d) 20 μm. Figure 1(a) qualitatively demonstrates that the small cubic table salt grains have a high surface area to volume ratio, thus providing many growth sites for the carbon dioxide in the Diet Coke. Figure 1(b) shows rough patches and nooks and crannies in the salt, which are also excellent growth sites. Figure 1(c) is a magnified view of the edges of a salt grain, and Fig. 1(d) is a magnified view of the top of a salt grain.

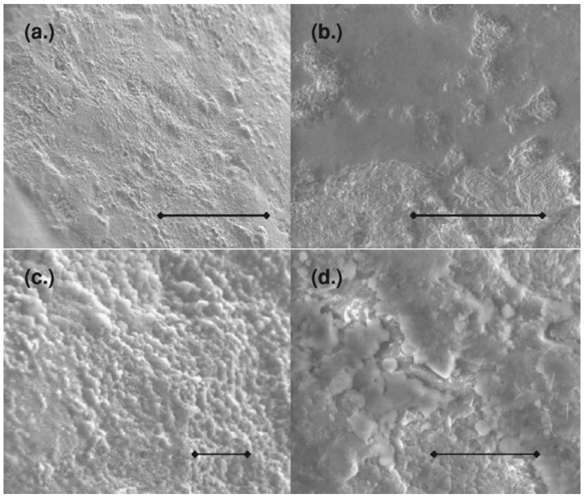

Fig. 2. SEM images of Mint Mentos [(a) and (c)] and Fruit Mentos with a candy coating [(b) and (d)]. The scale bars in each image represent the lengths (a) 200 μm, (b) 100 μm, (c) 20 μm, and (d) 20 μm. The images were acquired with a beam energy of 12.5 kV and a spot size of 5.0 nm. The lower magnification image of the Fruit Mentos has smooth patches in contrast to the lower magnification image of the Mint Mentos, but the candy coating is not uniform. The higher magnification image of the Fruit Mentos is zoomed in on one of the rougher patches.

The Mythbusters identified the active ingredients in the Diet Coke that contribute to the Mint Mentos–Diet Coke reaction: caffeine, aspartame, and potassium benzoate, a preservative.[1] As shown by the agreement within the 10% experimental error of the mass lost and distance traveled by the soda's spray for Mint Mentos in Diet Coke compared to Mint Mentos in Caffeine Free Diet Coke (see Tables I and II), the presence or absence of caffeine in the beverages contributes little to the reaction. Note that the contact angles for Diet Coke and Caffeine Free Diet Coke are not very different. If we assume that γ_{LV} is similar for Diet Coke and Caffeine Free Diet Coke, then the work required for bubble formation for Diet Coke is 90% of the work required for bubble formation for Caffeine Free Diet Coke. A 10% difference is comparable to the uncertainty in our experiments, and hence it is difficult to observe significant differences in the results for Diet Coke compared to Caffeine Free Diet Coke. Although this conclusion seems to refute the claims made by the Mythbusters, remember that in their experiments, Jamie

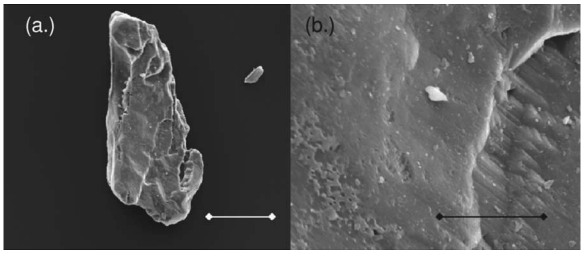

Fig. 3. SEM images of playground sand acquired at a beam energy of 20 kV and a spot size of 5.0 nm. The scale bar for (a) is 100 μm and for (b) is 20 μm.

Fig. 4. Sample contact angle images for (a) deionized water, (b) deionized water with added aspartame, and (c) deionized water with added potassium benzoate. Note that the contact angle for the aspartame and potassium benzoate solutions is less than the contact angle for pure water, indicating a decrease in the surface tension.

added “enough caffeine to kill you” to the seltzer water.[1] So the relatively small amount of caffeine in a 2 l bottle of Coke doesn’t significantly affect the reaction.

Drinks sweetened with aspartame, such as diet Coke or the diet tonic water, are more explosive than drinks sweetened with sugar (corn syrup), which is likely due to a reduction in the work required for bubble formation when aspartame is added. This conclusion is supported by our contact angle measurements showing a reduced contact angle for aspartame and water in contrast to pure water or sugar water (see Table IV).

We compared dropping 16 g of Mint Mentos into a 1 l bottle of seltzer water (carbonated water), a 1 l bottle of tonic water (carbonated water, high fructose corn syrup, citric acid, natural and artificial flavors, and quinine), and a 1 l bottle of diet tonic water (carbonated water, citric acid, natural and artificial flavors, aspartame, potassium benzoate, and quinine). The amount 540 ± 20 g of mass was lost from the diet tonic water, 430 ± 20 g of mass was lost from the tonic water, and 94 ± 5 g of mass from the seltzer water. The sugar reduces the contact angle more than pure water and causes more mass to be lost from the seltzer during the reaction, but more mass is lost by the beverages with potassium benzoate and aspartame.

The potassium benzoate also reduces the work of bubble formation, as shown by the reduced contact angle for water with added potassium benzoate (see Table IV). The potassium benzoate and the aspartame are active ingredients in the Mint Mentos–Diet Coke reaction, but the aspartame likely contributes more to the reaction. It is difficult to find beverages containing aspartame that do not contain a preservative such as potassium benzoate. To directly compare the aspartame with the potassium benzoate we dropped 16 g of Mint Mentos into a 1 l bottle of seltzer water with 7.5 g of added potassium benzoate and the same amount to a 1 l bottle of seltzer water with 7.5 g of added aspartame. The mass 410 ± 20 g was lost from the aspartame–seltzer water mixture and 360 ± 20 g of mass was lost from the potassium benzoate–seltzer water mixture. So aspartame causes the most mass lost. Given the ingredients listed on Diet Coke, there is more aspartame than potassium benzoate in Diet Coke per unit volume.

It might seem surprising that the Fruit Mentos perform as well or better than the Mint Mentos. To the naked eye, Fruit Mentos are shinier than Mint Mentos, and therefore should be smoother. In the Mythbusters episode[1] a Mint Mentos and a brightly colored Mentos were dropped into Diet Coke, and although the Mint Mentos caused the expected eruption, the brightly colored Mentos did almost nothing. According to our experiment, however, the SEM images show that the shiny, brightly colored coating on the Fruit Mentos is not uniform and rough patches are exposed (see Fig. 2.) Also, the coating dissolves very rapidly in water, and so is not effective at preventing the growth of carbon dioxide bubbles. Our AFM measurements show that the rms roughness of the Fruit and Mint Mentos surfaces are comparable (see Table V). All of our results seem to contradict the aforementioned Mythbusters experiment. However, the brightly colored Mentos

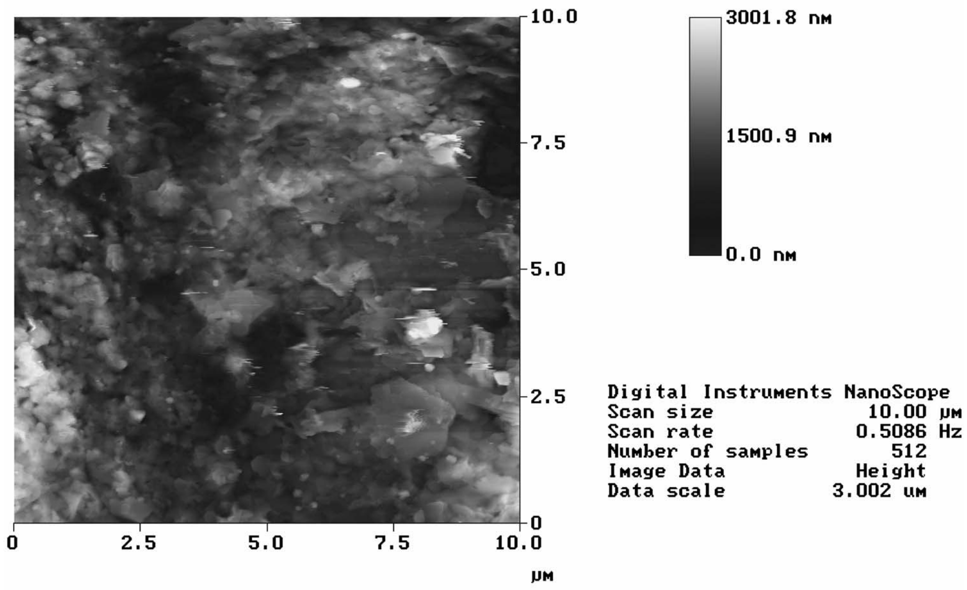

Fig. 5. Contact mode AFM image of Mint Mentos. The quantitative roughness information detailed in Table V was taken from this image.

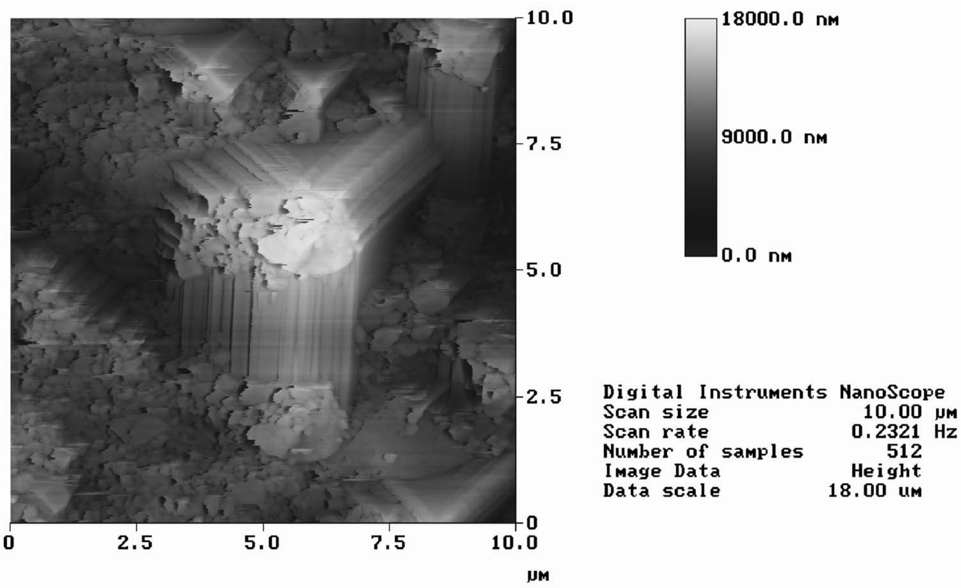

Fig. 6. Contact mode AFM image of Wint-o-Green Lifesaver. The quantitative roughness information detailed in Table V was taken from this image.

the Mythbusters dropped into the soda had a waxy coating added by the Mythbusters team, not the Mentos manufacturers.[1]

The speed with which the sample falls through the liquid is also a major factor. We used a video camera to measure the time it took for Mentos, rock salt, Wint-o-Green Lifesavers, and playground sand to fall through water from the top of the water line to the bottom of a clear 2 l bottle. The average times were 0.7 s for the Mentos, 1.0 s for the rock salt and the Lifesavers, and 1.5 s for the sand. The uncertainty of the fall times was roughly 10%. The sand and the table salt grains were roughly the same size, so we assume that the fall times for the sand and table salt would be comparable. The color combined with the small size of the salt grains made it too difficult to see, and therefore difficult to determine the time of fall for the table salt. From our results in Tables I and II we see that the rock salt performance far exceeds the table salt performance, even though the surface area to volume ratio (and hence the number of bubble growth sites per gram) is larger for the table salt. However, the larger rock salt pellets fall quickly to the bottom of the 2 l bottle, while the much smaller table salt grains fall more slowly due to their smaller weight and size. If the growth of carbon dioxide bubbles on the sample takes place at the bottom of the bottle, then the bubbles formed will detach from the sample and rise up the bottle. The bubbles then act as growth sites, where the carbon dioxide still dissolved in the solution moves into the rising bubbles, causing even more liberation of carbon dioxide from the bottle. If the bubbles must travel farther through the liquid, the reaction will be more explosive. Longer distances traveled by the bubbles resulting in a more explosive reaction also partially explains the differences in explosive power for whole Mentos in contrast to crushed Mentos; the smaller particulates of the crushed Mentos fall through the liquid more slowly. However, a change in surface roughness might also occur and affect the results when the Mentos is crushed. These claims are also supported by data from the liquid gum arabic trials. When the gum arabic was injected at the bottom of the bottle, 100 g of mass was lost. But when the gum arabic was injected into the middle of the bottle, no mass was lost.

There is not always a direct correlation between the mass lost and the distance traveled for the reactions. The most striking example is the molecular sieve beads, which lost a significant amount of mass but only traveled 2.5 ft. There are two major reasons for this discrepancy. Slight adjustments to the positioning of the spout on the bottle or small adjustments to the position of the bottle in the holder can cause the angle of the spray to change, which can affect the spray's range by several feet. A more dramatic effect is the rate of the reaction. If the reaction occurs over a longer time, more mass can be lost with a smaller explosion. (Compare the volcanic explosions of Mt. St. Helens and Mt. Kilauea, for example. Enough mass was deposited by the Hawaiian hot spot to form the islands, but the eruptions were comparatively gentle.) We found that the Diet Coke–Mint Mentos reaction lasted $\approx$3.8 s, the Diet Coke–Fruit Mentos reaction lasted $\approx$3.6 s, and the Diet Coke–Wint-o-Green reaction lasted $\approx$4.9 s. Compare these times to the mass lost and distance traveled results in Tables I and II. Of these three highly eruptive reactions, the Wint-o-Green reaction lasted the longest and lost a comparable amount of mass to the others, but traveled a much shorter distance than the Fruit and Mint Mentos reactions. (As discussed, part of the reason that the Wint-o-Green reaction took more time is due to the increased fall times.) The Fruit Mentos and the Mint Mentos reaction lost roughly the same amount of mass, but the Fruit Mentos reaction took place over a shorter time and therefore the spray traveled much farther than the Mint Mentos reactions. For the reaction between Diet Coke and the molecular sieve beads, the lower limit on the duration of this reaction was 12 s, a much longer time than all of the other reactions. The longer reaction time is due to the many growth sites associated with the porous molecular sieve beads. These growth sites are not all on the surface of the bead, and hence the Diet Coke has to soak into the bead through the pores.

The carbon dioxide attaches throughout the bead, increasing the amount of time over which the reaction occurs.

From Table III we see that higher temperatures lead to larger eruptions. This phenomenon is an illustration of Henry's law given in Eq. (4) next and Le Chatelier's principle.[6]

$$P = Kc. \tag{4}$$

Henry's law applies to gases dissolved in liquids, such as the carbon dioxide gas dissolved in Diet Coke and other sodas. In Eq. (4) P is the partial pressure of the gas above the liquid, K is a parameter, and c is the molar concentration of the gas. If the partial pressure of the gas above the liquid is higher, then more gas can be dissolved in the liquid. In a sealed bottle of soda pop, the gas above the liquid in the bottle has a high partial pressure of carbon dioxide compared to the air we breathe. So when a bottle of soda is opened, the partial pressure drops, and the molar concentration of the gas must also drop, which is why sodas go flat over time after they are opened. The parameter K changes with temperature, generally increasing as the temperature increases. This increase means that the molar concentration of the gas in the solution must drop for the same value of the partial pressure, which implies that gases become less soluble in liquids as the temperature increases. Le Chatelier's principle states that, "If, to a system at equilibrium, a stress be applied, the system will react so as to relieve the stress."[6] In our experiment the stress we are applying increases the temperature of the Diet Coke. This increase moves the system away from the equilibrium condition for that molar concentration of the gas. When we drop the Mentos in the heated Diet Coke, the system moves toward equilibrium by liberating the excess carbon dioxide from the solution via the explosive reaction.

Surface roughness has often been cited as the most important cause of the Diet Coke–Mentos reaction.[1–3] Increased surface roughness implies a higher surface area to volume ratio, meaning that more growth sites should be present on per unit volume. It is clear from Table V that the roughness of the sample is a major contributor to the explosiveness of the reaction. On a 100 μm^2 scale, the Wint-o-Green Lifesavers have a rms roughness that is more than a factor of 10 larger than the rms roughness of the rock salt. The Diet Coke–Wint-o-Green reaction loses more mass and the spray travels farther than the Diet Coke–rock salt reaction. However, the importance of the presence of surfactants in the Mentos cannot be denied. The Wint-o-Green Lifesavers are rougher than the Mentos by a factor of 5, but the mass lost during these reactions is comparable. The coating of the Mentos contains gum arabic, a surfactant that reduces the surface tension of water. The Diet Coke–liquid gum arabic and Diet Coke–Dawn/water mixture trials demonstrate that even without any surface roughness, the introduction of a surfactant into the soda causes a reaction. Hence it is the combination of a rough surface and the surfactant in the outer coating of the candy that causes the impressive reactions.

Some of the samples, such as the table salt, molecular sieve beads, and the sand grains, were too rough to image in our AFM, which has a 24 μm z range. We can, however, qualitatively discuss the sample roughness by examining the SEM images of table salt and sand grains in Figs. 1 and 3. The lower magnification images show large surface areas and small volumes, especially when compared to samples such as a Mentos, which is $1-2$ cm in diameter. The higher magnification images shown in Figs. 1 and 3 reveal jagged edges, pores, and seemingly rough surfaces (excellent growth sites for the carbon dioxide bubbles) for both table salt and sand grains. Based on these SEM images and our inability to image the samples in the AFM due to the limits on our z range, we assume that these samples have a roughness greater than those reported in Table V. Although these samples are rough, the fall times through the bottle, the duration of the reaction, and the lack of a surfactant contributed to a less impressive eruption for these samples.

IV. CONCLUSIONS

Due to the popularity of the Diet Coke–Mentos reaction as a demonstration of key principles in physics and chemistry, we have investigated the causes of the reaction. This demonstration illustrates many important ideas in physics, including key principles in thermodynamics, surface science, and the physics of eruptions. The Mythbusters correctly identified potassium benzoate and aspartame as key ingredients in the Diet Coke–Mentos reaction. We have shown here via contact angle measurements that these ingredients reduce the work required for bubble formation, allowing carbon dioxide to rapidly escape from the soda. Due to the small amount of caffeine in a 2 l bottle of Diet Coke, we do not agree that the caffeine in Diet Coke contributes significantly to the reaction. The Mythbusters also correctly identified the roughness of the samples as one of the main causes of the reaction. We showed the importance of sample roughness by comparing SEM and AFM images of the samples to the explosive power of the reaction. We also showed that samples which encounter less viscous drag and hence fall more quickly through the soda will cause a more explosive reaction. Also, for the same amount of mass lost, the eruption will be more dramatic when the reaction takes place over a shorter time. Finally, we have shown that hotter beverages result in a more explosive reaction.

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[a] Electronic mail: coffeyts@appstate.edu

[1] Adam Savage and Jamie Hyneman, "Episode 57: Mentos and Soda," Mythbusters, Discovery Channel, first aired August 9, 2006.

[2] Steve Spangler, “Mentos geyser-Diet Coke eruption,” ⟨www.stevespanglerscience.com/experiment/00000109⟩.

[3] Jack F. Eichler, Heather Patrick, Brenda Harmon, and Janet Coonce, “Mentos and the scientific method: A sweet combination,” J. Chem. Educ. **84**, 1120–1123 (2007).

[4] We used a FEI Quanta 200 electron scanning microscope.

[5] Pablo G. Debenedetti, *Metastable Liquids: Concepts and Principles* (Princeton University Press, Princeton, NJ, 1996), p. 218.

[6] Daniel V. Schroeder, *An Introduction to Thermal Physics* (Addison–Wesley Longman, San Francisco, CA, 2000), p. 216.

Impedance Bridge. The General Radio model 650-A Impedance Bridge was a standard fixture in physics laboratories until the 1970s. It was used as a Wheatstone bridge to measure pure resistances using the internal power supply (four big No. 6 dry cells) and the meter. Inductance and capacitance were measured using an alternating current bridge. The theory, known to all of us of certain age, involved the use of complex numbers, and the bridge had to be balanced for both the real and imaginary solutions, thus giving the resistance and the L and C values. The a.c. detector was a pair of magnetic earphones. This was a big piece of apparatus that cost $175 in 1935; the GR code word for it was “beast.” This example is in the Greenslade Collection. (Photograph and Notes by Thomas B. Greenslade, Jr., Kenyon College)