TEACHING PHYSICS WITH FOOD AND DRINK

The flight of the humble tea bag

Anyone for tea with a twist of lemon? Well here are a few new twists to the delightful 'flying tea bag' activity. This has been around in various incarnations for some time. In an early version a cylinder is formed from tissue and glued together using tiny pieces of gummed envelope flap. This is used as part of a magic trick to extract a dollar bill hidden in the burning tube (Brown 1984). More recently it has appeared in the *Physics Teacher* as the 'ethnic rocket' (Edge 1997) and in a very safety-conscious form on a science supplier's website (Carolina Biological Supply Company 2003).

I find that the tea bags that work best are those made from a tube of gauze folded in half that have a paper tab and thread stapled to them. You should:

- gently remove the staple and unfold the tea bag into a long cylinder;
- discard the tea leaves or use them to make yourself a cuppa in the traditional way;
- stand the tea-bag cylinder upright on a saucer or other non-flammable surface and light the top of the tea bag using a lighter or match.

The photograph on the left (above) shows the tea bag a couple of seconds after it was lit. The bag burns down and when there is about a centimetre of gauze remaining – just when you think nothing further will happen – the burning tea bag rises into the air and floats almost to the ceiling. The photograph on the right shows the tea bag at the point of lifting off. The remains of the burned gauze slowly falls back down to the floor as a fine clump of ash.

Do tea bags have wings? The tea bag shortly after it was ignited (left) and burning away happily. QuickTime and AVI movies of the experiment are available from stacks.iop.org/physed/39/22.

It's all hot air

The burning tea bag causes a column of hot air and gas from the combustion to rise above it due to convection. When the bag becomes light enough it is carried up in the convection current. Shorter cylinders are less reliable because the gauze needs to burn for a sufficient length of time to produce a good convective updraught. (By the way, my tea bags had an average mass of 0.15 g before burning but the remaining ash did not register on the sensitive balance that I used.) The thermal conductivity and specific heat capacity of the ash are other considerations that can be explored. The tea bag does not damage the table and the ash won't burn you.

The tea bag doesn't damage the table (see photograph above) because most of the heat rises by convection and only a small amount is radiated downwards. There is no conduction of heat to the table because the gauze has minimal thermal conductivity. Even if the burning tea bag falls over, most of the heat rises. Nor will the ash burn you – the smoldering ash has only a minute heat capacity due to its tiny mass. A saucer should be provided in the activity to remove student concerns prior to discussing the issue of heat transfer to the table.

I prefer to conduct the 'flying tea bag' as a whole-class activity to maximize student participation. I hand out one teabag, a saucer and a lighter or box of matches to pairs of students. One student in each pair undoes the tea bag and opens it out into a cylinder. Later the other student lights the tea bag.

Before this stage, however, I use a POE strategy to initiate and guide scientific thinking in the activity. POE stands for Predict – Observe – Explain (Gunstone 1995). I briefly tell the students what they are about to do and ask them to predict how the teabag will burn. All ideas are collected. Several possibilities usually emerge and I get students to vote for which they think will result.

When predictions are sufficiently discussed and anticipation has grown, I get the students to light the tea bags simultaneously. They then observe, often with accompanying 'oohs' and 'ahhs'. Then

I ask for their 'ideas' to explain why the tea bag 'flies up' and use these ideas to draw out a satisfactory explanation of the event. A useful question is: 'Where else have you seen something like this?', to which many talk about ash rising from a bonfire.

Finally I like to relate this activity to the process in which warm air rises above the land during the day and above the sea at night, giving rise to breezes.

Always read the fine print

Here are some words of advice:

- The tea bag cylinder is easily blown over by small currents of air, so windows and doors should be closed to eliminate cross draughts.
- For the same reason you need to be careful how you extinguish matches if you use them – I have seen people topple the cylinder while blowing out the match.
- If the cylinder falls over while it is burning, just leave it where it is and try again later – there is not enough time to right it and have the tea bag rise successfully. You should warn students before they do the activity to leave the tea bag alone once it is burning.
- Afterwards I talk to students about always doing this activity under supervision. I encourage them to demonstrate it to their parents but not to repeat it by themselves or with friends.
- Recently I've found that some tea-bag makers have changed their manufacturing method. Some bags now have a waxy crimp in the middle and another to attach the thread. As a result it's not possible to make a tall enough cylinder, so these modifications effectively make them useless for the activity. Unfortunately the packaging hasn't changed, so the suitability of the tea bags can't be determined before you buy them.
- It pays to have plenty of tea bags available because students always want to do the activity again. One of my student teachers demonstrated the burning tea bag to his associate teacher while on practicum last year. Immediately the activity swept through the school like wildfire (sorry) as science teachers found inventive ways to justify doing it in their very next science lesson.

References

Brown R J 1984 *333 More Science Tricks and Experiments* (Blue Ridge Summit, PA: TAB Books) pp40–41

Carolina Biological Supply Company 2003 *Tea-Bag Rocket* www.carolina.com/chemistry/experiments/teabag.asp

Edge R D 1997 String and sticky tape experiments: the ethnic rocket *Phys. Teacher* **35** 110

Gunstone R F 1995 Constructivist learning and the teaching of science *Teaching and Learning in Science: the Constructivist Classroom* ed V Prain (Sydney: Harcourt Brace) pp3–20 (see pp13–14)

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