"Smart" Paper – Detailed Activity Instructions

**Introduction**

Hand out absorbent paper, lemon juice and q-tips. Have students write their name on the top corner of the page in regular ink, then ask them to write a message, or draw a picture on the paper in lemon ink. Have students set the paper aside till later. You should also write two messages and set them aside.

Give all students 3 sheets of carbonless copy paper, (A,B,C). Guide students to write on top sheet and observe what happens to the bottom two. Instruct students to move the order of the sheets, A C B, C A B, B A C, the order C B A will give the desired result, copying from the top sheet to the other two. Then ask the students to flip the middle B sheet so that the B faces down instead of up have them write on the top sheet again (no copying will occur).

Two discussions can be lead: How does this paper work and is this paper advantageous to use.

Have a volunteer come up to help with the next demonstration. Give them a sheet of plain white computer paper and white thermal paper. Ask if there is any ink on the paper. Then have them hold the iron on top of the thermal paper and computer paper for a few seconds. CAUTION: clothing irons can get very hot, make sure no one touches the metal part of the iron or severe burns could occur. Hold up both sheets of paper, the thermal paper will have an ink mark on it where the heat touched the paper.

**Microcapsules**

- **Starting Questions**

  Ask students: what is the smallest thing you have seen with your eyes? What is the smallest thing you cannot see with your eyes, but you know exists?

  Mention that the paper they were just playing with contains tiny capsules they cannot see which hold invisible ink, called “microcapsules”. Ask students what they think a microcapsule is. If they need ideas, ask what something micro is, then ask what a capsule is used for.
**Demonstration Procedures**

Ask for different examples of capsules we use every day that are intended to contain liquids or solids and release them in a certain way: M&M’s, eggs, gushers, paintballs, bath beads, scratch and sniff stickers.

Talk about the different ways that you can break the capsules discussed, and what is actually being used to rupture the shell. Bring up “melts in your mouth” (i.e. heat transfer), or how you crack an egg (i.e. mechanical pressure or force), or scratching, dissolving (medicine).

Ask what would happen if you could put ink into a tiny capsule? What would you put it on? How would you release the ink?

Ask for a volunteer. Give volunteer lightest cylinder, discuss differences between that and stainless steel cylinder. Ask which spheres will break the paintball and why. Have a different student drop lightest cylinder, which should not break the paintball.

Ask students what they think will happen when larger cylinder is dropped, have them drop heavier cylinders. Have students drop different cylinders and observe any differences in noise, splatter, etc. Explain that it is not the breaking of the capsules in the paper that creates the image, rather it is the “reaction” that occurs when the ink inside the capsule comes in contact with other chemicals in the paper that brings out the color.

Ask students what problems they see with putting tiny capsules on paper that can be broken, and how they think paper makers get around these problems. Have students try and break a bath bead, ask why it would be a good thing to not always be able to break a capsule.

Bring up the other methods discussed earlier for breaking a microsphere, stressing heat. Ask if a similar method could be used (only with heat) for releasing ink.

Introduce thermal paper as being similar to carbonless, but with different types of spheres all over, sensitive to heat not pressure.

Ask how we could use this technology to print? Could we develop something similar to the printer we have on our computer?

Have them draw an analogy to the splatter box: what would we use to represent the printer instead of a heavy cylinder? (iron, hot metal rod of some sort)

Ask about advantages of having the ink inside the paper, where only heat is needed to develop an image?

Again stress that it is a multi-step process. The capsule walls are broken (either with heat or force), which releases the ink inside, which combines with other chemicals in the paper to form an image.

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**Invisible ink**

Have students inspect the absorbent paper that they wrote on with lemon juice. Ask them if they can see the lemon juice ink. Explain that the lemon juice is like invisible ink, similar to the ink in the microcapsules. Like the ink in the microcapsules the ink can become visible when it mixes with something else and reacts, like red cabbage juice.

Spray red cabbage juice on a sheet of absorbent paper that has been written on with lemon ink (in a tray or on newspaper) and show students. Have all students spray their own sheet of paper (in trays or on newspaper).

You can also demonstrate that addition of heat (using an iron) can also turn the lemon ink colors.
Another reaction you can demonstrate using the glow stick. Have a student start the stick (this is done by bending the stick and breaking the capsule inside the stick to allow the reacting chemicals to come into contact with each other).

Wrap up

Have you ever seen an example of any of the technologies we have talked about today? Can you think of any cool ways to use microspheres? Discuss how they are used to kill the engine of a battleship.

Rehash fundamentals of how carbonless and thermal paper work.

Can put kids into groups. Ask them where they might have seen smart paper before, advantages of having the ink already in the paper, disadvantages of smart paper, and possible uses for this technology.

Hold up various examples of “smart” and “dumb” paper. For example, airline tickets, concert tickets, lottery tickets, grocery receipts, and have them vote yes or no on whether they think microspheres are in the paper.

Ask them if they noticed anything, comment on how often they “see” this technology without even realizing it

Tell them they can quiz mom or dad at home: ask parents for a grocery receipt, and whether they think ink is in the paper. Then tell them to lightly iron the paper and see what happens. Demonstrate for the class.

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