OUTREACH ACTIVITY PROPOSAL

Polymer Cross-linking

A 12-minute polymer chemistry demo for middle school

AUDIENCE	GROUP SIZE	DURATION	BUDGET
Middle school *Grades 6–8*	50 students	12 minutes *Single block*	$120 total *$2.40 / student*

> *Most polymer demos build a polymer. This one builds one and dissolves another within the same 12-minute block.*

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01 Overview

Fifty students work through two hands-on segments back to back, and the same ionic cross-linking chemistry runs in opposite directions across a single 12-minute block. In the opening segment, we have the students cross-link sodium alginate with calcium ions to form solid "worms," while in the second segment they dissolve a hydrogel of sodium polyacrylate by adding sodium ions, which screen the carboxylate charges holding the gel open. The polymers are familiar from disposable diapers, bubble tea, and dental impressions, so the system is presented through materials the students already encounter outside the classroom.

Both procedures are established teaching demonstrations with a documented record in the chemistry education literature. The alginate-calcium reaction was first published as a teaching demonstration in 1998 [1] and continues to appear in current outreach activities from the American Chemical Society [2], the Royal Society of Chemistry [3], and Science World [4]. Sodium polyacrylate is the active absorbent in disposable diapers and is a standard reagent for teaching super-absorbent polymer chemistry [5].

02 Learning objectives

By the end of the session, each student will be able to:

- Define a polymer as a long chain made of repeating units (monomers).

- Explain that cross-links between chains turn flexible chains into a three-dimensional network with new properties: stiffness, gel formation, absorbency.
- Describe how ions (Ca^{2+}, Na^{+}) can act as cross-linkers or charge-screeners, and how swapping ions can build or break a polymer network.
- Identify at least three polymers in their everyday environment and connect them to the chemistry they just performed.

03 Standards alignment

The two-reaction structure addresses two Next Generation Science Standards for middle school physical sciences [6]. **MS-PS1-2** (analyze and interpret data on the properties of substances before and after the substances interact) shows up twice in the same session: liquid to solid as alginate cross-links, then solid gel back to liquid as salt collapses the polyacrylate network. **MS-PS1-3** (describe how synthetic materials come from natural resources and impact society) is built into the choice of reagents. Sodium alginate is extracted from brown seaweed [3]; sodium polyacrylate is a synthetic acrylate polymer used in disposable diapers, agricultural water retention, and wound dressings [5].

04 Activity run-of-show

Single 12-minute block with three facilitators. Each student's tray is pre-loaded with materials before students enter the room.

TIME	SEGMENT	WHAT HAPPENS
0:00–1:00	**Hook: the diaper trick**	Pre-loaded cup with sodium polyacrylate. Pour water, swirl, flip upside down. Nothing falls out. "This was in your diaper when you were a baby. Today you're going to figure out how it works."
1:00–2:30	**30-second polymer crash course**	Pass around a paper-clip chain (monomer → polymer). Then a second chain clipped onto the first: "this is a cross-link. Everything cool about polymers comes from controlling these."

TIME	SEGMENT	WHAT HAPPENS
2:30–8:00	**Hands-on #1: alginate worms**	Each student gets a pre-filled syringe of colored 2% sodium alginate and a cup of 1% calcium chloride. Squirt in → instant worm. Challenge: longest unbroken worm. Talking points while they work: Ca^{2+} cross-links the guluronic acid blocks of adjacent chains; the same chemistry is used in boba pearls, wound dressings, and dental impressions.
8:00–10:30	**Hands-on #2: diaper polymer and salt reversal**	Each student gets a cup with about ½ tsp sodium polyacrylate. Add water → instant gel. Then add a pinch of salt and stir → it collapses back to liquid. "You just broke the polymer. Na^{+} from the salt screens the charges on the polymer chains, so they no longer repel each other and the network collapses. That's why pee, which is salty, eventually overwhelms diapers."
10:30–12:00	**Land the punchline**	Hold up a hair tie and a pencil eraser. Both are rubber. The hair tie stretches because its chains have few cross-links between them; the eraser resists because it has many. Same polymer, different cross-link density. That tuning is how one polymer becomes running shoes, contact lenses, or car tires. "Same trick you just did, with calcium ions instead of vulcanization." Bag worms for take-home.

05 Materials and budget

All consumables and reagents are listed below. Quantities include about 20% overage for spills, demonstration practice, and turnout variance. All chemicals are food-grade or educational grade. Sourcing notes follow in section 06.

ITEM	PURPOSE	QTY	COST
Sodium alginate (food-grade, ~100 g)	Cross-linkable polymer; ~12 g consumed for 50 students	1 unit	**$15**
Calcium chloride (food-grade, e.g. Ball Pickle Crisp, 5.5 oz)	Cross-linker bath for alginate worms; ~30 g consumed	1 unit	**$10**
Sodium polyacrylate (1 lb, educational grade)	Super-absorbent polymer; ~150 g consumed	1 unit	**$25**

ITEM	PURPOSE	QTY	COST
10 mL Luer-slip syringes (no needle), 100-pack	Pre-fill with alginate solution; 1 per student plus spares	1 pack	**$15**
9 oz clear plastic cups, 100-pack	Calcium chloride bath	1 pack	**$8**
2 oz soufflé cups with lids, 100-pack	Sodium polyacrylate portioning	1 pack	**$10**
Sandwich-size zip bags, 100-pack	Take-home worm storage	1 pack	**$4**
Plastic stirring sticks	Stirring polyacrylate gel	1 pack	**$5**
Food coloring set	Color the alginate solution for visibility	1 set	**$5**
Table salt (1 lb)	Reversal step for polyacrylate	1 box	**$2**
Paper towels	Spill management	2 rolls	**$5**
Contingency (~15%)	Replacement reagents and disposables		**$16**
	TOTAL FOR 50 STUDENTS		**$120**

OPTIONAL ADD-ONS

Not included in the $120 baseline. Add as needed.

OPTIONAL ADD-ON	NOTES	COST
Splash-resistant safety goggles, 50-pack	Required if venue does not provide and school policy mandates eye protection.	**$80**
Disposable nitrile gloves (100-pack)	Optional. Calcium chloride at 1% is a mild irritant; gloves are for comfort.	**$10**
Take-home info card, printed (1 per student)	One-page parent-facing summary of the chemistry.	**$15**

OPTIONAL ADD-ON	NOTES	COST
Printed leader script and station signs	Reference material for volunteer facilitators.	**$5**

06 Sourcing notes

Sodium alginate and calcium chloride are available food-grade from Modernist Pantry, Amazon (under “spherification” listings), or restaurant supply specializing in molecular gastronomy. $CaCl_2$ is also sold in grocery stores as Ball Pickle Crisp (about $7 for 5.5 oz). Sodium polyacrylate is sold by Educational Innovations (product GB-6) [5], Steve Spangler Science, and Amazon; the educational grade is what to order, not the industrial water-treatment grade. Luer-slip 10 mL syringes (no needles, sold for crafts and pet medication) ship in 1–2 days from Amazon.

07 Staffing and logistics

Staffing requires one lead facilitator and two assistants. The lead runs the script, manages timing, and runs the demonstration moments: hook, paper-clip analogy, closing. The assistants distribute pre-portioned materials, circulate during the two hands-on segments, and hand out the polyacrylate cups at minute 8. Tables should seat six to eight students with paper towels and a trash bag at each table. Plan 25 minutes of pre-event setup and 15 minutes of cleanup. If 50 students cannot be seated simultaneously, the activity runs as two back-to-back 12-minute sessions of 25 students with a 5-minute reset between.

08 Pre-event preparation

Sodium alginate dissolves slowly and clumps if added too quickly to water. This is the most common failure mode for the demonstration. Whisk powder slowly into warm water or pulse in a blender, then let stand overnight for full hydration [1].

- **Sodium alginate solution (2%).** Whisk ~10 g powder into 500 mL warm water. Refrigerate overnight. Add food coloring, then pre-fill 55 syringes with ~5 mL each.
- **Calcium chloride solution (1%).** Dissolve ~25 g $CaCl_2$ in 2.5 L water. Portion ~50 mL into 55 clear 9 oz cups; cover with plastic wrap.
- **Sodium polyacrylate.** Portion ~½ tsp into 55 soufflé cups, lidded. Do this in a still room to keep powder out of the air.

- **Salt.** Pour table salt into 2–3 shakers, one per table.

09 Safety

- **Eye protection.** Required. Chloride solutions above 10% are eye irritants per CLEAPSS Hazcard HC047b [3]. At 1%, the working concentration here, the risk is low, but goggles are standard practice and required by most school policies.
- **Sodium polyacrylate.** Same superabsorbent polymer used in disposable baby diapers; sold as a science-education reagent by Educational Innovations for K–12 classroom use [5]. Avoid airborne powder during portioning. Once mixed with water, the gel is safe for direct hand contact.
- **Calcium chloride and sodium alginate.** Both are food-grade ingredients. $CaCl_2$ is sold as pickle crisp; sodium alginate is used in commercial ice cream and molecular gastronomy [1]. Skin contact is safe; hand-washing after is sufficient.
- **Allergies.** Sodium alginate is derived from brown seaweed; no documented allergenic risk in chemistry education use. No latex, no nuts, no common allergens in any of the materials.
- **Disposal.** All polymer products go in regular trash. $CaCl_2$ and salt solutions go down the sink with running water [2], [4]. No special hazardous-waste handling.

10 Outcomes and take-home

Each student leaves with a sealed sandwich bag containing their alginate worm in water, stable for about a week refrigerated. If the optional info card is included, students also receive a one-page parent-facing summary of the chemistry and a list of polymers in everyday objects.

Baseline cost is $120 for 50 students ($2.40 per student); optional add-ons bring the maximum to $230. Leftover sodium polyacrylate and unused disposables from the 100-packs cover one to two additional sessions of the same size at marginal cost.

11 References

[1] The Alginate Demonstration: Polymers, Food Science, and Ion Exchange. Journal of Chemical Education 1998, 75 (11), 1430. https://doi.org/10.1021/ed075p1430

[2] American Chemical Society. Goo Worms (outreach activity). https://www.acs.org/education/activities/goo-worms.html (accessed May 2026).

[3] Royal Society of Chemistry. Cross-linking polymers – alginate worms (class experiment). https://edu.rsc.org/experiments/cross-linking-polymers-alginate-worms/691.article (accessed May 2026).

[4] Science World. Insta-worms. https://www.scienceworld.ca/resource/insta-worms/ (accessed May 2026).

[5] Educational Innovations, Inc. Sodium Polyacrylate (Diaper Polymer), product GB-6: educational guide and safety information. https://www.teachersource.com/product/sodium-polyacrylate-diaper-polymer (accessed May 2026).

[6] NGSS Lead States. Next Generation Science Standards: For States, By States. The National Academies Press: Washington, DC, 2013. Standards MS-PS1-2 and MS-PS1-3.