AN ARTISTIC EXPLORATION

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Can integrating the art and aesthetics of lithography in an inquiry-based approach to chemical reactions strengthen student understanding and help them develop important skills in science? What questions, discussions, and digressions emerge from such an approach? What role does the teacher play in facilitating such explorations?

An experiential inquiry-based approach to teaching science may not only strengthen conceptual understanding, but also go beyond topic-specific learning outcomes to help students develop important skills in the practice of science. These include observation, critical questioning, abstract thinking, verbalizing gaps in understanding (self-awareness), experimentation, and collaboration (practical skills). Can we deepen such learning experiences by offering space for students to work with a sense of mindfulness and beauty?

To explore this question, I introduced the fundamentals of chemical reactions to Grade VII students using the art of lithography (see **Box 1**). I knew that this kind of hands-on work was likely to capture their attention. My decision was also guided by the fact that the students in my class had been exposed to a variety of artwork, and enjoyed creating art themselves. And some of them had shown a capability for the practical skills needed for this kind of artwork.

Box 1. What is lithography?

The term lithography is derived from two Greek words—'lithos' meaning 'stone' and 'graphein' meaning 'to write'. Based on the immiscibility of oil and water, it uses simple chemical processes to create images on a flat surface. In its simplest form, an image (called the positive image) is drawn on a flat rocky surface (like, limestone or marble) with a hydrophobic (water-repelling) medium (like, wax crayons, oil paint, or nail polish). An aqueous acid solution is used to etch off the negative image (the unpainted parts of the surface) to impart 3-dimensional features to the surface. One could also attempt to combine the visual effects of both positive and negative images while choosing a pattern for etching.

Aims of the activity

One aim of this activity was to strengthen an understanding of important concepts in chemical reactions. Students in this age group had not yet been introduced to the atomic structure of matter, but showed a factual understanding of chemical reactions in terms of the properties of substances and some preliminary ideas about acid-base reactions. While some students seemed to appreciate topics involving the nomenclature and classification of matter, quite a few did not relate to the abstract nature of these topics. All the students were quite curious to observe some of the chemical changes that they had heard and read about.

The other, broader, aim was to help students develop a propensity to work and inquire together, and to explore concrete experiences as a scientist would. Such activities inevitably draw out interesting questions and comments from students. While the plethora of questions addressed to the teacher can sometimes be daunting, I feel that only some of these questions need answers. Some others may need some refinement by the teacher. But many questions could be left, perhaps with some pointers, with students for their own exploration. For the teacher, this last category of questions can be seen as an invitation to participate in the way students make sense of things. They reveal the nature of the student's mind that is simultaneously observing, questioning, trying to offer explanations, and connecting their thinking to everyday experience.

The activity

I started the activity by introducing students to the marble slabs and sea shells that we were to use as our base material (see **Activity Sheet I**). I also explained the overall process and the expectations involved (see **Fig. 1**).

During steps 1 and 2, I invited creativity by encouraging students to work in groups and use nail polish to paint any shapes they agreed upon on the surface of the base material. The teacher may need to ensure that there is good understanding and alignment within each group on what to draw.

Step 3 was a teacher-led phase. Each slab was immersed in an aqueous hydrochloric acid solution used as an etchant and kept in a shallow transparent plastic pan to allow us a clear view. The students were encouraged to observe the entire process and record their observations and any thoughts that occurred to them.

In steps 4 and 5, the etched sample was washed with plain water and the paint was wiped off with acetone. Students were then able to see, touch, and feel the etched surface. Each group was encouraged to observe and correlate the effects of their drawings on the etched marble surface. From a purely aesthetic point of view, they were also encouraged to repaint the figures as they wished, using watercolour, crayons, or ink to give finishing touches to their samples (see **Fig. 2**).

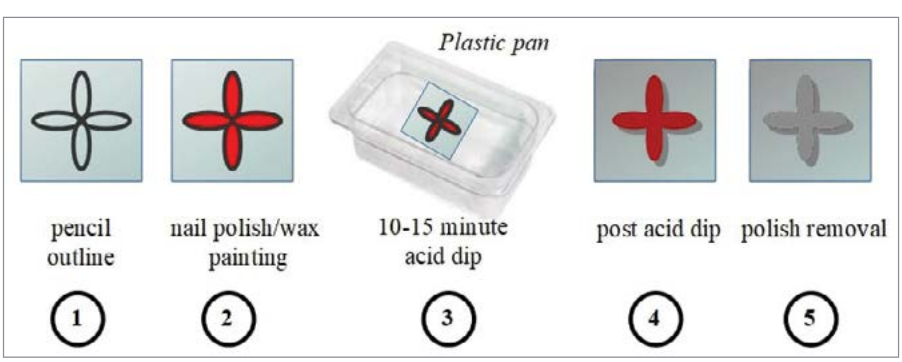

Fig. 1. Different steps involved in acid etching.
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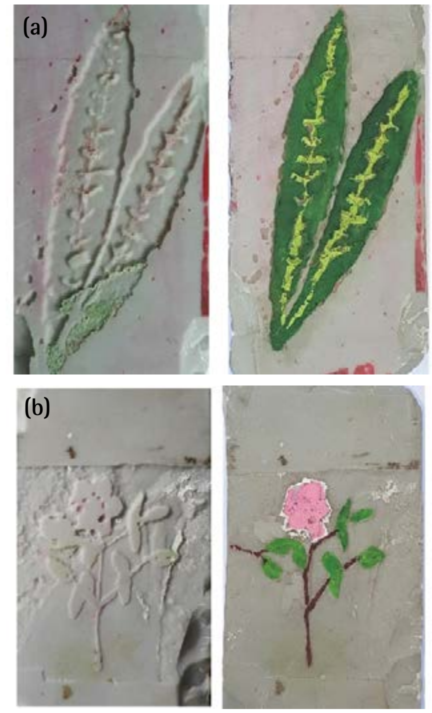

Fig. 2. Some examples of repainting. The twin leaves in (a) and the flower in (b) have been repainted.
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Trigger questions: connecting science processes to experiences

Throughout the activity, but particularly during its last stage, students came up with many questions, observations, and new ideas to implement in a second run. It was a joy to watch them discuss these with each other, and make new connections. Here are some of their questions and comments along with some notes on their background, and the kind of learning they may lead to:

Question: *"Can we use citric acid or vinegar to etch designs on any stone? Can I use this method to make stone jewellery in the holidays?"*

I pointed out that this method may not be appropriate for 'any stone or metal'. I also indicated that this was a great idea, provided students could use this method of etching at home in a safe manner. Towards this goal, I suggested that they could start by using kitchen vinegar with some citric acid on marble tiles or chalk stone surfaces.

Box 2. Would acid etching stop by itself?

We decided to explore this possibility by letting this experiment continue for the duration of an entire class. The students observed that the rate of appearance of bubbles (that appeared at the start of the reaction) showed a gradual slowing down and stopped completely after about 15-20 minutes. They also observed that by this time the marble slab looked porous and diminished. Student groups were invited to discuss this observation and offer some explanation for it. Two interesting responses emerged:

a) Just like the solubility of sugar in water, there may be some limit to how much marble gets dissolved by acid;

b) Since the acid and the marble are in the same solution, the marble may have mixed with the acid, making the acid more and more impure. This might explain the slowing down of the reaction.

One can see these very natural and logical connections the students had arrived at while trying to explain their observations (also see **Teacher's Demonstration: Is Acid Etching Self-limiting?**). One may pause here and wonder what brings about such reasoning in preadolescents. Is it exposure to scientific literature, discussions, or just a developmental outcome? Is this an outcome of early age involvement in observational activities? Are some social factors also involved? Perhaps multiple factors may contribute to the development of such intelligence. Such instances seem to suggest that it may be possible for young minds to discover the fundamental questions of science even within the constraints of today's classrooms and syllabi.

Question: *"How fine can the carvings be? Can I draw hair-like lines?"*

The student was trying to contrast this chemical etching technique with a stone carving process that she was familiar with. Having observed the effort (energy) it takes to use a chisel to carve a slab of stone, she was wondering if the removal of matter from a marble surface through chemical etching also needed some energy. My response was to convey that chemical processes also involve work at a microscopic level.

Question: *"What are those whitish powdery things? Is that marble powder? How small can we cut a piece of marble so that it still is marble?"*

Here the student was referring to a powdery white substance that was formed during the reaction. She was unsure if this powder came from inside the marble piece. This question brings to mind early scientific debates about the nature of matter at microscopic scales. Atomists like Democritus used pure reasoning to suggest that there was a lower limit to dividing a grain of sand while retaining the properties of sand.

Question: *"Where does the etched-out marble vanish? What would happen to the marble if we leave it inside the acid solution for a long time?"*

This student wondered if it were possible for the acid to "eat up" the whole slab if the reaction was allowed to continue long enough. In other words, she wanted to know if this process would ever stop by itself (see **Box 2**).

Comment: *"As long as the acid solution touches just the surface, etching should continue. The entire slab need not be inside the solution."*

This comment came from a student who was interested in using less acid for the activity (see **Box 3**).

Question: *Is it possible to 'anti-etch' or 'grow' something on the surface of the slab?*

One group explored the possibility of drawing their "story" by combining both negative (etch) and positive (anti-etch) images on the same slab. While a negative image adds depth to the figure, a positive image renders an upward projection (see **Fig. 3**). They described this as an interesting challenge since they had to shift their attention between the two drawing techniques (see **Fig. 4**). While most of them seemed to like experimenting in this way for the fun of it, a student questioned if it was possible to combine both the techniques in a

Box 3. Can we use less acid for etching?

We made some changes in the setup to explore this possibility (see **Activity Sheet II: Less Acid for Etching**). In the modified set-up, we decided to place the slab upside down to ensure that only the surface to be etched would be in contact with the acid solution. Since the slab would be only partially immersed in the solution, we would be able to use much less acid for etching. To achieve this, we used four plastic bottle caps of the same dimensions to support the marble slab.

In spite of making a couple of attempts to set this up, it did not seem to work. The students and I wondered what could be preventing the etching from taking place. On closer examination, we observed that the slab surface that was in contact with the acid solution was covered with bubbles (which meant that the reaction had started), but these bubbles weren't rising up to the surface as in the previous set-up. Many of the students suggested that the bubbles could somehow be preventing the reaction from proceeding further. While this wasn't a full explanation, it offered a significant insight—the film of carbon dioxide may be preventing contact between the acid and the marble surface. Once I drew what I thought could be happening on the blackboard, most of the students seemed to understand this possibility better.

Getting clarity about a phenomenon is definitely valuable, but what is more significant is the way in which the mind arrives at such clarity. I hoped that a significant takeaway from this experience, at least for some students, was about how performing science experiments can surprise us (and scientists) at times.

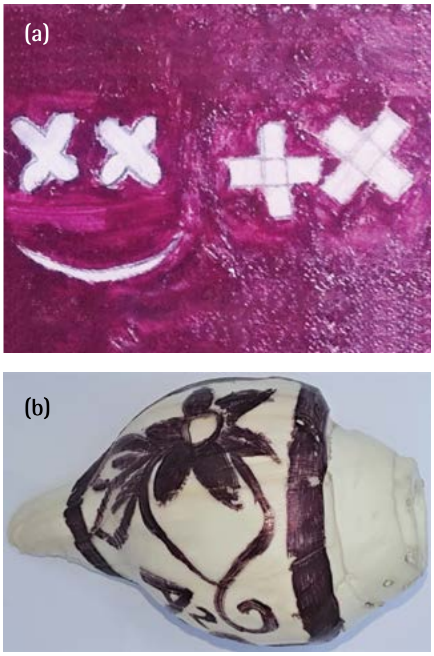


Fig. 3. The results of etching and anti-etching techniques. (a) A negative image of the crescent moon and stars. Here the background is painted with nail polish. Since this is hydrophobic, the acid solution reacts only with the exposed, unpainted surface. The moon and stars show depth. (b) A positive image of a flower. Since the flower areas are painted with nail polish, the acid solution will react only with the unpainted background. The flower will look elevated.

Fig. 4. Combining etching and anti-etching techniques. A student group imagined a trip to an island. To the left of the image is a pair of coconut trees, and to the right is a boat anchor. This was created in such a way that the trees have gone down from the surface and the boat anchor has come up. Part of the student group was busy improvising the story. Clearly, a lot more was happening than just the learning of chemistry concepts!

single figure. While this response was not directly related to a chemistry concept, the student's ability to sense this new possibility is an example of a creative act in the learning process—a trait to be encouraged.

Some reflections

(a)Discussion as a way of learning: Interesting discussions kept happening intermittently throughout the activity (see **Box 4**). The extent to which the students were interested in each other's questions, suggestions, and explorations was quite remarkable. These discussions were broadly about the nature of matter at microscopic levels, explaining an observation, sharing an insight by a student, and so on. It was as if the group had a mind of its own! Many students showed increasing self-awareness, in the sense that in attending to others' ideas and explanations, they became more aware of their own thinking. It was also interesting to see how some students were able to bring the class to a common understanding.

(b) Expanding and deepening connections: Such an integrated, inquiry-based teaching style allows many opportunities for deeper mental connections to be formed. For example, this activity allowed multiple possibilities of connecting various concepts while offering interesting digressions (see **Fig. 5**). Many potential digressions may be explored to break the monotony of the class. I feel that such contextual digressions bring about a reflective mood and may help in forming deeper mental connections.

Parting thoughts

Areas as diverse as arts, games, and cooking can offer many opportunities to teach science in a hands-on and fun-filled manner. The challenge for a science educator is to identify aspects of these areas that lend themselves to understanding specific concepts in the science curriculum, and to convert them into grade-appropriate activities in a creative manner. It is my submission that such science activities can help sustain the attention of a group without much coercion.

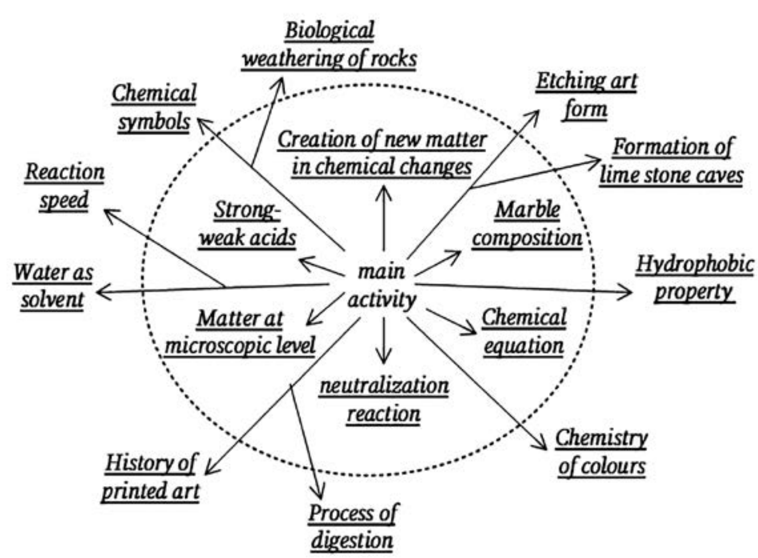


Fig. 5. A mind map that can be used by teachers for planning the activity. Such maps help link various concepts and ideas, and also in making directed and meaningful digressions in the classroom.

Box 4. **A sample of interesting discussions:**

(a) On the nature of the acid:

Student A: *"Sir, the acid is in the water solution. But why does the smell hurt so much?"*

Student B: *"Perhaps the acid is evaporating from the water."*

My response: *"Yes, some acids evaporate from the solution. In general, the solution may contain substances that evaporate at different temperatures and at different rates. In this solution, hydrochloric acid evaporates more easily than water. That is what is hurting your sense of smell. It is the smell of hydrochloric acid in the air."*

Student C: *"You had mentioned that many acids are naturally found in gaseous form. Does this make it easier for such acids to escape from solutions?"*

This student was trying to apply the ideas of acids and bases introduced during earlier classes to a new question. This included the understanding that fire, which is a chemical reaction, tends to separate acids and bases—air takes up acids in the form of emanating smoke, and the earth (soil) takes up bases in the form of ashes. Thus, many acids (like CO_2 and HCl) are found in gaseous form, and many alkalis (like $CaCO_3$) are found in soil. It also drew from the understanding that water dissolves both acids and bases, and the reaction of these two solutions is called a neutralization reaction.

(b) On the reaction products:

My question: *"What do you think about the white powdery substance that is created when the reaction is going on? What could that be?"*

Student D: *"It must be marble powder."*

Student E: *"But when we break a regular marble slab, the powder does not come out like this. It must be something else."*

Student F: *"Is it something like rust in the iron bar experiment? Rust is different from iron, and did not exist before rusting...."*

Recognizing the formation of new substances is key to understanding any chemical process.

(c) On the hydrophobic nature of substances:

Student G: *"Sir, why is it that only the unpainted area reacts to the acid? Why does the painted area* **not** *react to it?"*

My response: *"Observe the surfaces in the painted and unpainted areas that are in contact with the acid. In the painted areas, the acid solution is in contact with the nail polish. So what do you think the nail polish does to the painted area?"*

Student H: *"Oh okay... So, the nail polish makes the reaction slower? That may be why the unpainted area gets etched faster."*

My response: *"Some substances like to 'stay away' from water even if they are dropped in water. Substances with this property are called 'hydrophobic'. Some examples of such substances are oil, nail polish, oil paint, fat, grease, and wax."*

Student H: *"So if the water in the acid solution has to touch the marble surface, it has to go through the paint, which it cannot do because of the nail polish. Right?"*

My response: *"Yes, that's right."*

Student G: *"But it is the acid which etches, and not water."*

Student H: *"Buddy, the acid is contained in the water. If the water cannot touch the surface, how can the acid touch it?"*

Box 5. **Some suggestions for the teacher:**

- Encourage students to observe things that they may have overlooked, and to probe some of their observations more deeply.
- Be open to co-approach ideas and concepts, and be tentative about them. This involves a capacity to be attentive and tolerant about how ideas take shape in students' minds, and then come to a common understanding.
- Pay close attention to the exchanges that take place within each group since it can give insights into the way students think on their own and in a group. Several ideas for experiments to extend the activity may emerge during these exchanges.
- Use the blackboard to draw mind maps to show the connections that students identify between the activity and chemistry concepts in their curriculum. These may include chemical reactions such as neutralisation (identifying the reaction and reaction products), the chemical composition of marble and chalks, weak and strong acids, etc.
- Through this activity try and bring about a 'fun, but still relevant' element in learning.

By increasing avenues for individual exploration, this approach can also be more effective in getting students with diverse interests, abilities, aesthetic sensibilities, and skill levels involved in the learning process. In addition, it empowers students with the 'art of exploration' and imparts a 'sense of ownership', both of which bring vitality to the learning process (see **Box 5**). Students not only learn the required concepts in chemistry, they tend to cherish such experiences till long after.

Our Chemical World

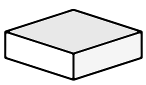
ACTIVITY SHEET I : ACID-ETCHING

Aim:

To explore if:
1) Drawings can be etched on a marble slab or shell surface using chemicals.
2) This activity can be used to understand various introductory topics in chemistry.

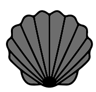
What you need:

Surface to etch on (1 per group of students)



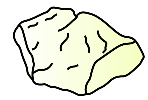
Marble slab of any shape with at least one plane surface to paint on

or

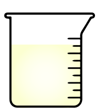


Sea-shell of any dark shade (medium size so that you can hold it and paint on it)

or

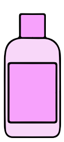


Any "fizzy rock" (a rock that is reactive to acid, like limestone, chalk stone) that is easily available locally with at least one plane surface to paint on



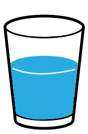
10% to 20% by volume of aqueous hydrochloric acid solution (add acid to water rather than water to acid)

Any quick-drying water-resistant acrylic liquid paint (like nail polish) of any colour (1 bottle per group of students)

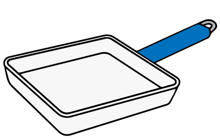


Acetone or nail polish remover (about 50 ml) to clean any left-over paint or drawing mistakes on the surface

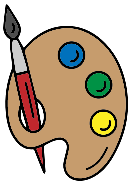
Some cotton or a piece of cloth to rub acetone against the surface if needed



Some tap water to wash the stones or shells after acid etching



A shallow transparent plastic pan



A variety of watercolours and crayons to repaint/ decorate the surface after etching is over

What to do:

(a) Painting

- Discuss within your group and agree on what you would like to draw on the base surfaces (marble slab or shell) provided. Start by drawing the selected design on paper before you paint it on the base surface.
- Identify two people from your group to do the drawing. Use coloured nail polish to slowly and carefully paint the agreed-upon shape on the base surfaces. You can use nail polish brushes or painting brushes for this purpose.

- Clean the base surface with acetone if you would like to re-draw or modify the shape. This can be done multiple times to ensure that everyone in the group is satisfied with the final artwork. (Hint: starting with a paper-pencil drawing can help minimize the number of such iterations).

(b) Acid etching
- Give your group's painted sample to your teacher, who will carry out the acid etching step, one sample at a time.
- Observe the acid etching demonstration carefully. Record any observations, questions and ideas that your group comes up with. Particularly look for signs to suggest the starting and ending of any change in your sample.

(c) Cleaning
- Observe how your sample is cleaned to remove any acid residue before it is handed back to you.
- See, touch, and feel the texture of the etched surfaces. Compare the etching with your original drawing. Record your observations. Also, make note of any differences you notice between the kind of finish you expected and the actual surface finish.

(d) Finishing (Optional)
- Wipe off the nail polish colours by rubbing it with cotton or a piece of cloth dipped in acetone.
- Use watercolours or crayons to give finishing touches to your drawings.

Think about:

- Why is nail polish used to draw shapes for etching?
- Why is acetone used to wipe away the nail polish?
- What changes do you observe when the base surface is: (a) placed in the tray? (b) left in the acid solution? (c) removed from the tray? (d) washed with water? (e) cleaned with acetone to remove the nail polish? How would you explain these changes?
- What changes do you observe in the colour, texture, and appearance of: (a) the 'drawn' and 'not drawn' surfaces of the base material, and (b) the hydrochloric acid solution in the tray? How would you explain these changes?
- Why do you think bubbles were formed when the base surface was placed in the acid solution? Why do the bubbles come up to the surface of the solution? Have you seen something similar elsewhere?

i wonder... Rediscovering school science

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Azim Premji University

ACTIVITY SHEET I: ACID-ETCHING

1. Two consecutive classes can be used on different days. In the first class, students can understand the process and finish the artwork. The second class can be used for the teacher-led demonstration of acid etching.
2. This is designed as a group activity. Break the class into groups of 2-4 students each to ensure maximum participation by all the students.
3. Explain the activity step-by-step, the time required, and the precautions to be taken in each step.
4. Introduce the students to the materials they will be using as the base for their etching. Give each group one piece of marble slab or shell and tell them that they are going to paint on the surface which will be etched eventually.
5. Use the blackboard to explain hydrophobic and hydrophilic properties. Explain clearly which areas of the surface will get etched by acid due to the acid-base reaction.
6. Clearly explain which tasks will be performed by the student groups and which ones will be demonstrated by the teacher. Also, instruct the students to observe and take notes during the demonstration.
7. Some groups might need help deciding what to draw on their base surface. Also, the students who are chosen to paint images on the base material may require support and guidance to do this with care. Nail polish brushes are not as firm as a paintbrush, and using these may require dexterity and careful manipulation.
8. Make students aware of specific precautions that must be taken in handling acetone and acids in general:
   - Acetone is volatile and flammable and can irritate the skin, nose, and eyes. Ensure that the activity is done in a well-ventilated area. Students should avoid contact with acetone. In the event of contact, ensure that they wash the contact area thoroughly.
   - Use acid-alkali gloves when handling hydrochloric acid, and explain to students the importance of using protective gear when handling corrosive acids, solvents, and alkalis.
   - Explain the safety aspects of mixing acid and water to students. Specify why it is safer to add acid to water rather than the other way around.
9. For the demonstration of the etching step:
   - Prepare etchant (diluted acid solution) by adding concentrated hydrochloric acid (37% standard solution) to distilled water in the shallow pan. Ensure that you slowly add the concentrated acid to the water in the ratio of 10% to 20% by volume. If the acid is too dilute, the reaction may take longer. Decide the final volume of the solution depending on the size of the base materials.
   - Using acid-alkali gloves, immerse each sample carefully in the etchant for about 10-15 minutes. Make sure that the surfaces which need to be etched are facing upwards.

- Draw your students' attention to the appearance of bubbles as it signals the start of the reaction. Ask students to note when the reaction slows down (typically after 10 to 20 minutes of immersing the samples depending on the initial strength of the acid solution) and stops.
- Remove the pieces 5 minutes or so after the bubbles have disappeared. You may continue with the next fresh piece with the same solution. If the reaction does not happen or the solution has become cloudy, prepare a new solution for each new set of etchings.
- One or more samples can be etched together depending on the volume of etchant. However, the etching tends to get shallower as the number of samples increases. One can try this out with 1 or 2 samples at first and then decide. This can be a point of observation and discussion.
- Wash the etched samples with tap water to remove any residual acid.

10. Encourage the students to make their observations and record them as a group. Clarify that this activity is an invitation to think and discuss as a group.

TEACHER'S GUIDE

i wonder...
Rediscovering school science

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Azim Premji University

Our Chemical World

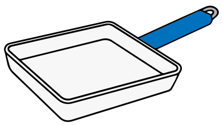
TEACHER DEMO : IS ACID ETCHING SELF-LIMITING?

Aim:

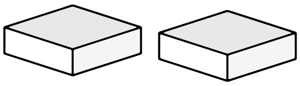
To explore if:
1) The reaction between the marble and the dilute acid solution stops by itself.
2) The concentration of the acid affects the reaction time.

What you need:

100 mL each of 10% by volume of aqueous hydrochloric acid solution.



A shallow transparent plastic or glass container to hold the acid solution.



Two small pieces of marble that are as close as possible to each other in shape, size, and weight; and can be easily placed in the plastic tray. The weight of each piece should be between 20–30 g.

What to do:

1. Clean both marble pieces with tap water. Ask the students to weigh the two pieces of marble and make note of their weights. Use this step to confirm that the two pieces have identical weights.
2. Gently place the first piece of marble in the 10% acid solution. Ask students to record the time when bubbles start appearing (indicating the start of the reaction). Also, ask the students to record the time when the bubbles stop appearing (end of the reaction).
3. Use a pair of tongs to pull the marble piece out of the acid solution and wash with tap water. Ask the students to weigh the washed marble piece and make note of the weight.
4. Put the marble piece back in the same batch of 10% acid solution. Leave it for 10-15 minutes. Take it out again, wash it, and ask students to weigh the piece again.
5. Repeat steps 2-3 of the experiment with the second piece of marble.
6. Put the second marble piece in a fresh batch of 10% acid solution. Leave it for 10-15 minutes. Take it out again, wash it, and ask students to weigh the piece again.

Ask students to record:

	Piece 1:	Piece 2:
Initial weight (grams)		
Weight after the 1st round of etching (grams)		
Weight after the 2nd round of etching (grams)		
% weight change		
Duration of appearance of bubbles in 1st round of acid etching (minutes)		
Duration of appearance of bubbles in 2nd round of acid etching (minutes)		

Ask students to think about:

- With each marble piece, was there any difference in the duration of appearance of bubbles between the first and second rounds of etching?
- What was the % weight change in each of the two marble pieces after the first and second rounds of etching?

Invite students to discuss:

- Why do bubbles form during acid etching? Can you think of any reasons for this observation?
- Compare the % of weight change in each of the two marble pieces after the first round of etching. Was there a difference? Can you think of any reasons for this difference?
- Compare the % of weight change in each of the two marble pieces after the second round of etching. Was there a difference? Can you think of any reasons for this difference?
- Compare the duration for which bubbles appeared in the first round of etching. Was this different for the two marble pieces? Can you think of any reasons for this difference?
- Compare the duration for which bubbles appeared in the second round of etching. Was this different for the two marble pieces? Can you think of any reasons for this difference?
- Do you think that acid etching is self-limiting or ends by itself? What factors help end this reaction?

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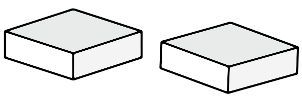
Our Chemical World

ACTIVITY SHEET II : LESS ACID FOR ETCHING

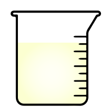
Aim:

To explore if etching an upside-down (inverted) marble surface will involve less HCl solution.

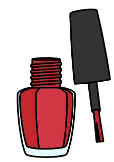
What you need:



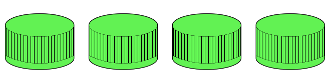
Two marble slabs that are identical in size, shape, and weight; and have at least one plane surface (preferably with an area of 2-3 square inches) of identical dimensions on each



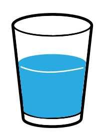
20% by volume of aqueous hydrochloric acid solution



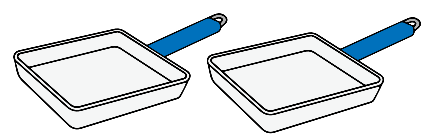
One bottle of nail polish of any colour



Four identical plastic bottle caps to support one of the slabs



Tap water to wash the slab after acid etching



Two shallow transparent plastic pans

What to do:

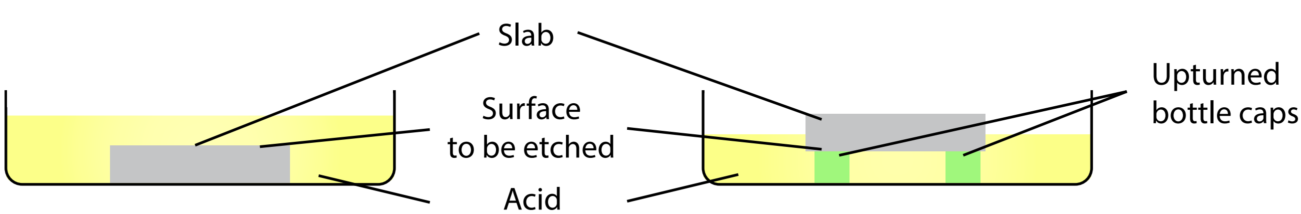
(a) Painting on the marble slabs

- Paint all the surfaces of both the slabs with nail polish except the flat surfaces where etching is supposed to happen.
- Leave aside for 5-10 minutes to let the paint dry.

(b) Setting up acid etching:

Assemble the following acid etching set-ups (see Figures A and B).

- Set-up 1 (see Figure A): Take one of the plastic pans and place the 1st slab inside it with its flat surface facing upwards.
- Set-up 2 (see Figure B): In the second plastic pan, place the 2nd slab with its flat surface facing downwards and supported by the four bottle caps.



Set-up I

Set-up II

(c) Acid etching (this step is a teacher demonstration)

- Observe how your teacher slowly pours acid solution into both the set-ups. This volume must be enough to cover the upward-facing surface (which is to be etched) of the slab in Set-up I, and the lower-facing surface of the slab in Set-up II. The volume of acid needed in Set-up II will be much less than that needed in Set-up I.
- After bubbles stop appearing, observe how your teacher uses a pair of tongs to pull out each of the slabs and then washes it under tap water to remove any residue of the acid.
- Observe the extent and quality of etching on both slabs.

Observe and think about:

- How long does it take for bubbles to appear in Set-up I? Where do they appear? How long does it take for the bubbles to stop appearing?
- How long does it take for bubbles to appear in Set-up II? Where do they appear? How long does it take for the bubbles to stop appearing?

Discuss:

- Compare the two set-ups for the number of bubbles and the rate at which they appear. Do you see any differences? If yes, can you suggest any reasons for the difference?
- Compare the extent and quality of etching on both slabs. Do you see any differences? If yes, can you suggest any reasons for the difference?

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Key takeaways

- It is useful to plan classroom activities that encourage an understanding of science concepts through art and aesthetic work.
- Activity-oriented classes allow a multi-sensorial and 'fun' approach to learning. Students get an opportunity to relate to concepts through their own observations, feelings, and experiences. This may aid better attention and deeper learning.
- It is important for the teacher to lead the class, but not at all times. If student groups can be encouraged to work together, they listen and learn from each other; examine, extend and trim down each other's reasoning; and, sometimes, bring the majority of the class to a common understanding.
- Such an approach may allow the teacher to facilitate the development of some psycho-emotional skills that are crucial to the practice of science. These include observation–listening–thinking, working together, intelligent guesswork, as well as the ability to make sense of information and make connections.

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Note: Source of the image used in the background of the article title: A collage of triangles. Credits: Ranjit Kumar Dash. License: CC-BY-NC.

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