

Sample	Observation	Interpretation of Result
Chicken toes	Eliminate & Tongliao: Toe turned red and flesh detached from bone or became jelly-like after 4 days. Other alkaline commercial drain cleaners made it soft after 2 days. Homemade ones: No observable change	Sodium hydroxide and sulphuric acid were corrosive and capable of causing severe burns with deep ulceration and permanent scarring. They can penetrate to deeper layers of skin and corrosion will continue until removed. The formation of the jelly-like fleshy part was probably due to the production of gelatin which is a processed version of a structural protein called collagen found in many animals, including human.
Aluminum foil & Zinc foil	Al dissolved in most alkaline drain cleaners. <i>Eliminate</i> dissolved both metal foil. Homemade ones: No observable change	Aluminium and zinc formed water-soluble complex with hydroxide ion. So they dissolved in alkaline drain cleaners. $\text{Al}_2\text{O}_3(\text{s}) + 2\text{OH}^-(\text{aq}) + 3\text{H}_2\text{O}(\text{l}) \rightarrow 2[\text{Al}(\text{OH})_4]^- (\text{aq})$ $2\text{Al}(\text{s}) + 6\text{H}_2\text{O}(\text{l}) + 2\text{OH}^-(\text{aq}) \rightarrow 3\text{H}_2(\text{g}) + 2[\text{Al}(\text{OH})_4]^- (\text{aq})$ In <i>Eliminate</i> ($\text{H}_2\text{SO}_4(\text{l})$), soluble ions were formed. $\text{Al}_2\text{O}_3(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Al}^{3+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$ $2\text{Al}(\text{s}) + 6\text{H}^+(\text{aq}) \rightarrow 2\text{Al}^{3+}(\text{aq}) + 3\text{H}_2(\text{g})$ $\text{Zn}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{H}_2(\text{g})$
Iron nail	Rusting occurred in all samples but it was less serious for alkaline ones than acidic one and homemade ones.	$2\text{Fe}(\text{s}) + \text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \rightleftharpoons 2\text{Fe}^{2+}(\text{aq}) + 4\text{OH}^-(\text{aq})$ initial $4\text{Fe}(\text{s}) + 3\text{O}_2(\text{g}) + 2\text{nH}_2\text{O}(\text{l}) \rightarrow 2\text{Fe}_2\text{O}_3 \cdot \text{nH}_2\text{O}(\text{s})$ overall Rusting tended to happen faster in acidic solution. It was inhibited in alkalis because presence of hydroxide shifted the equilibrium position of the above equations to left and suppressed metal Fe to lose electrons. Yet, <i>Pipeman (gel)</i> did not agree with that. This might be due to the presence of other unknown chemicals which overrode the effect.
Cloth & Wood	A black mixture formed after <i>Eliminate</i> had been added. Alkaline one turned wood to yellow and soft. No observable change for homemade one.	<i>Eliminate</i> acts as a dehydrating agent which removes hydrogen atoms and oxygen atoms in the ratio of 2 : 1, leaving carbon. NaOH in alkaline one removed hemicelluloses and lignin in wood and softened the wood.
Gloves	There was no observable change in all cases.	Gloves remained intact and thus can be used to protect our skin from the corrosive chemicals.

Hence, drain cleaners should not be applied to the products made of the above materials e.g. sinks. The homemade ones caused less destruction and had less vigorous reactions. So they are safer to use.

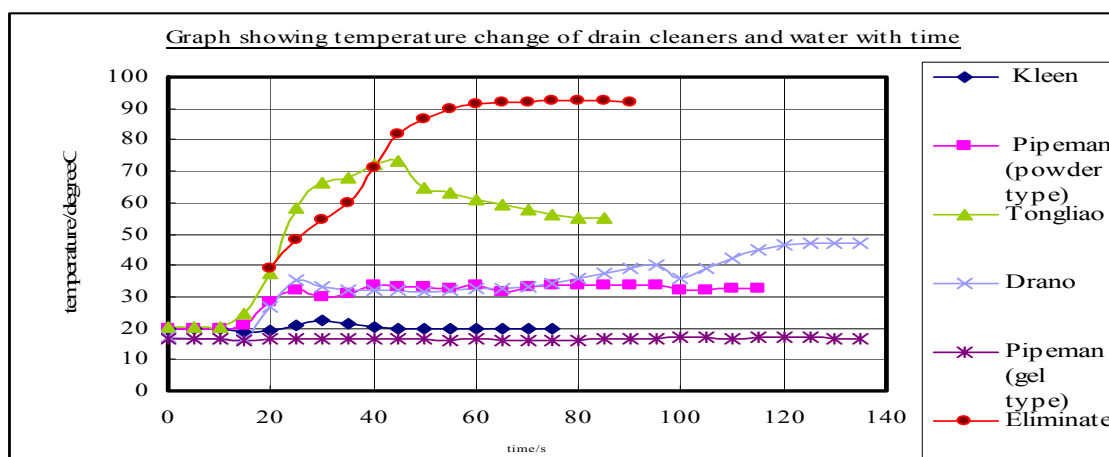
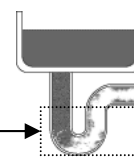
Part 3: Test for Temperature Change for commercial drain cleaners

When drain cleaners react with water, heat is usually given out. Yet, it would be dangerous if the heat evolved were high enough to boil the water inside (*max temperature rise should be less than 100 °C.*) Thus, amount of water and drain cleaners added should be reduced in proportion. By $\Delta E = mc\Delta T$, assuming that *m* and *c* of the resulting solution are constants, ΔE would be proportional to ΔT . The maximum amount of drain cleaner that can be used without boiling the water is determined and rate of temperature change can be compared.

Part 3-1 Fixed mass (10g) of samples were added to fixed volume of water (i.e. 90 cm³ which equals to 1/3 of the minimum volume of water which can be held by the tub under the sink.) A data-logger and temperature sensor was used to measure the temperature change with time.

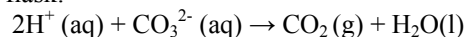
Part 3-2 Increasing amount of drain cleaner samples were added to 90 cm³ of water.

The maximum temperature change of *Eliminate* was the greatest and fastest (rose 92.58°C in 60s). For *Drano*, it almost reached 100°C when only 25g was added which was much smaller than the amount of sample used (30g) in the instruction. The reaction would be very vigorous and extremely dangerous. Thus, smaller amount was suggested to be used.



Part 4: Test for Pressure Change for homemade drain cleaners

Upon mixing of the ingredients of homemade drain cleaners, carbon dioxide was formed in the acid base reaction; high pressure would then build up inside the stoppered suction flask:



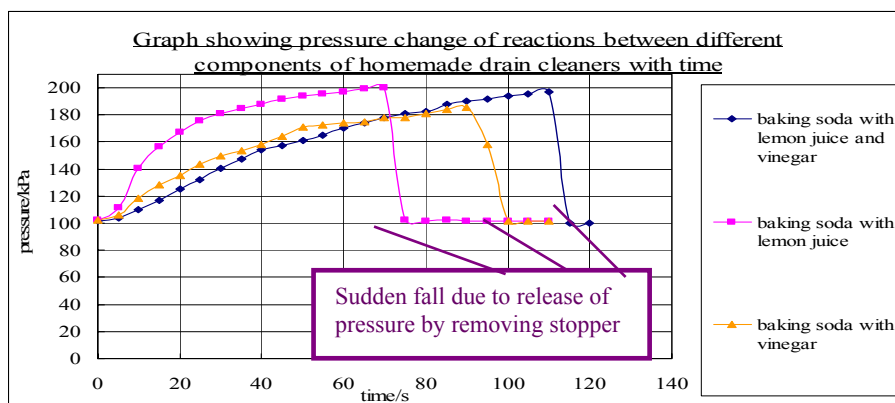
Procedure:

5g baking powder was added to 30 cm³ of vinegar or lemon juice solution in a suction flask and a data-logger and pressure sensor was used to determine the pressure change with time. The suction flask was pressed tightly during mixing.



Experimental diagram

It was found that the increase in pressure of mixing was up to nearly 200kPa. The rate of reaction when baking soda and lemon juice were mixed was the fastest and pressure was built up very quickly. Hence, this recipe was chosen as the most effective.



Part 5: Unclog the Pipes Test

To simulate the real situation of pipes blockage in kitchens and toilets, two kinds of blockage mixtures designated for kitchens (fats, vegetables) and toilets (hair, shampoo etc.) were made.

Procedures:

1. The materials were mixed up uniformly and 1cm thick blockage was sucked up in rubber tubes.
2. 5cm³ of water was added to be the accumulated water in tub and to ensure no error due to leakage.
3. To compare the effectiveness, time taken for unclogging was recorded. If the process did not complete within the given time i.e. 30 minutes, the volume of solution drained out was measured.

An average was taken by repeating the experiment. Among the commercial brands, *Eliminate* and *Tongliao* were more effective. They unclogged pipes by chemical reactions and the reaction was completed in about 5 minutes. Yet, for the other commercial ones, the blockage remained stuck and unclogging was unsuccessful. Only a few drops of solution were drained out after standing overnight. The homemade ones were found to be more effective than all commercial ones. They did so physically by generating large pressure and unclogging could be done within 10 seconds.

Further study

- (1) Quantitative tests could be performed to determine the amount of active ingredients in each drain cleaner.
- (2) The reaction of drain cleaners with other households chemicals such as bleaching solution could be studied.
- (3) The 'unclog pipes test' could be repeated using different compositions of blockage materials found in pipes. Different types and shape of pipes could also be used.
- (4) The ratio of the ingredients of homemade drain cleaners could be varied to determine the critical amount used.

Conclusion

Experimental results showed that *Eliminate* performed the best among the commercial brands. The generation of great heat and its highly corrosive nature contributes to its effectiveness in unclogging pipes. However, *Eliminate* was also the most dangerous to use. The heat liberated during reactions may cause spattering of chemicals and soften plastic (PVC) pipes. There are potential hazards of accidental spillage.

After considering all the factors under investigation and putting safety as our first priority, we have chosen *TongLiao Drain Cleaner* as the best from the commercial brands. It was less corrosive. Yet, it worked quite well in unclogging pipes.

To conclude, homemade drain cleaner (baking soda and lemon juice) is chosen as the best buy. Not only does it give less potential hazards and is more environmentally-friendly, but is also able to unclog pipes effectively by developing large pressure. The only limitation is that effective unclogging has to be carried out in an enclosed system and consumers should cover the mouth of the pipes tightly.

Therefore, handle the drain cleaners with care e.g. wear gloves and let's give a try to the homemade ones!

