# STUDENT WORKSHEET

## Substituting alcohols

### Topics

Properties of alcohols, replacing hazardous chemicals, substitution, green chemistry.

### Objectives

* Students learn about different properties of alcohols such as solubility and combustibility.
* Students learn how to compare an old laboratory procedure with a new laboratory procedure. In the new protocol, the most hazardous alcohols are either substituted or excluded from the protocol. The students then evaluate whether they will recommend replacing the old procedure with the new one.
* Students learn how to use principles of green chemistry to evaluate which of two laboratory procedures is most sustainable.

### Introduction

The solubility of alcohols in water decreases with increasing carbon chain to hydroxyl group ratio. Short chain alcohols, such as ethanol and propanol, are completely soluble in water while n-octanol is just slightly soluble in water.

Alcohols with short carbon chains undergo almost complete combustion under the conditions in this experiment. As the carbon chains gets longer, the alcohols will undergo incomplete combustion.

### Lab equipment

#### Old laboratory procedure

* 5 x graduated pipette
* 5 x test tube
* Test tube rack
* 3 x evaporating dish
* Matches
* Water

#### New laboratory procedure

* 4 x graduated pipette
* 4 x test tube
* Test tube rack
* 3 x evaporating dish
* Matches
* Water
* Marker

### Chemicals

#### Old laboratory procedure

* Methanol
* Ethanol
* Propan-1-ol
* Butan-1-ol
* Pentan-1-ol

#### New laboratory procedure

* Ethanol
* Propan-2-ol
* Butan-2-ol
* Pentan-1-ol

### Safety information

Mandatory personal protective equipment: goggles, lab coat and fume hood/ fume cupboard. Before starting, it is necessary to carefully read the instructions for safe work. After finishing, the used substances must be poured into specially prepared containers.



### Procedure

#### Old laboratory procedure

1. Solubility in water: Label the test tubes 1–5 (representing the amount of carbon atoms in the alcohols) and place them in the test tube rack. Add approximately 1 mL of the correct alcohol to each test tube. Add 2 mL of water to each test tube and stir. Which alcohols are completely mixable with water? Can you observe the trend in the water solubility for the alcohols?
2. Burning the alcohols: Add 1 mL of methanol to an evaporating dish, add 1 ml of ethanol to another evaporating dish and add 1 mL of propan-1-ol to a third evaporating dish.
3. Place the evaporating dishes on a surface that withstands heat. Set fire to the three alcohols and observe the flames. What differences do you observe in the flames? How can you explain these differences?

#### New laboratory procedure

1. Solubility in water: Label the test tubes 2–5 (representing the amount of carbon atoms in the alcohols) and place them in the test tube rack. Add approximately 1 mL of the correct alcohol to each test tube. Add 2 mL of water to each test tube and stir. Which alcohols are completely mixable with water? Can you observe the trend in the water solubility for the alcohols?
2. Burning the alcohols: Add 1 mL of ethanol to an evaporating dish, add 1 ml of propan-2-ol to another evaporating dish and add 1 mL of butan-2-ol to a third evaporating dish. Place the evaporating dishes on a surface that withstands heat.
3. Set fire to the three alcohols and observe the flames. What differences do you observe in the flames? How can you explain these differences?

### Results and discussion

1. Write down your observations from testing the water solubility of the alcohols and from observing the flames for both the old and the new laboratory procedure.
2. Communicate your results with presentations and reports using tables, graphs and/or charts.
3. Use relevant principles of green chemistry to compare the two procedures.
4. Evaluate which of the two procedures that is best in a green chemistry perspective.
5. Evaluate which of the two procedures that is best suited to make students learn about different properties of alcohols such as solubility and combustibility.
6. Present your evaluations of the two procedures to a peer or a group of peers. Discuss similarities and differences in your evaluations.

### Conclusion

Consider all the evaluations that you have made about the old and the new laboratory procedure. Would you advise that the old procedure is replaced with the new one, or would you advise that the old procedure is still to be used when students are to learn about properties of alcohols? Explain your answer.