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SUSTAINABLE ALTERNATIVES TO OIL BATHS

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INTRODUCTION

Oil baths are predominantly found in Chemistry labs and are used for specific chemical reactions. A container, such as a flask, is secured in place in the oil which is then heated to a specific temperature (up to 230°C). Essentially an oil bath is a container of oil heated up by a hotplate or hotplate stirrer. Often combined with the apparatus is a water cooled condenser. Working with the University of Oxford an experiment was carried out to evaluate the cost of running a specific reaction.

THE REACTION

Working with Dr. Antonio Martinez-Martinez a two-step reaction was carried out which required heating at 50°C and vapour condensing for a period of 16 hours. This reaction in detailed in Figure 1.

Reaction	Requirements
Reaction carried out in an inert argon atmosphere, 15 g scale reaction: Step 1: Grignard reaction at room temperature (exothermic reaction). Step 2: boron reagent preparation using the Grignard from Step 1 reaction carried out in an inert argon atmosphere, 15 g scale reaction.	Step 2: Heating to 50°C for 16 hours and condensing of vapour for 16 hours.

Figure 1. Reaction used for comparing technologies

This reaction was carried out using two systems. The first system used the traditional apparatus where the oil was heated by a hotplate stirrer with its vapour condensed using a water cooled condenser. This system was compared to the same model of hotplate stirrers; however, this time the oil bath was replaced by a 500 mL Heat-On block (plus adapter plate) with a PTFE cover. Instead of using a water cooled condenser, the air cooled condenser (a Findenser) was used (Figure 2). Both systems were set up by Dr Martinez- Martinez and water and energy usage were monitored.

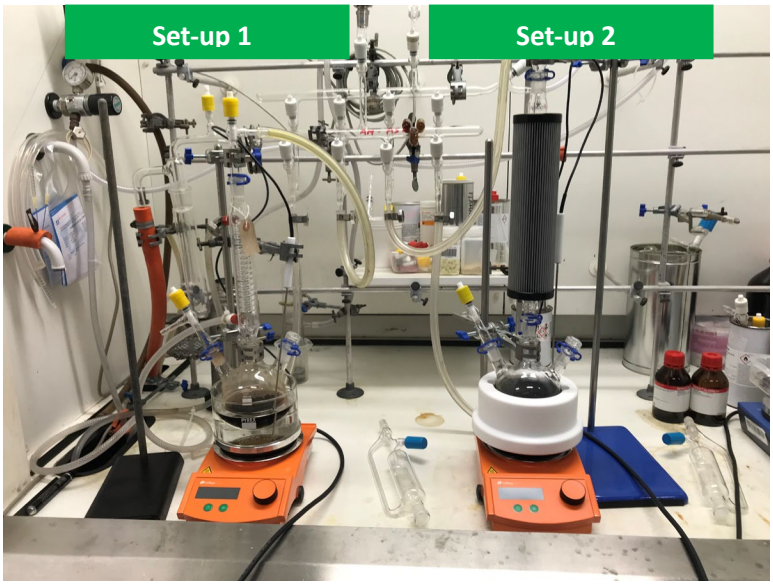

Figure 2. Comparing the two systems: Set-up 1. Oil bath and water-cooled condenser (left), Set-up 2. Heat-On block and Findenser (right).

RUNNING COSTS

The two systems demonstrated a considerable difference in their running costs. When looking at the energy consumption data, the oil bath system used 84% more energy than the Heat-On block system.

	System	
	Oil Bath with Water Cooled Condesner	Heat-On Block with Findenser
Energy Consumption	1.12 kWh	0.61 kWh
Water Consumption	757.44 Litres	0 Litres
Oil Cost/Year	£180	£0

Figure 3. Costs of running step 2 of the reaction

The data shown in Figure 3 is for a single run of the reaction. Based upon the feedback from researchers, the savings and payback periods associated with running this reaction have been calculated (Figure 4). The figures are based upon running the reaction four times per year, once a month and twice a month. The payback periods were calculated for two packages, the first being the price for the full system shown in Figure 2 (priced at £1337) the second package is for the system less the hotplate stirrer (priced at £664).

Reactions Carried Out/Year	Water Saved (m3)	Cost of Water Saved	Cost of Oil Saved	Cost of Electricty Saved	Full System Payback	Heat-On & Findenser Payback
4 (once quarterly)	15.149	£ 35.90	£ 180.00	£ 32.00	6.9 Years	4.3 Years
12 (1 per month)	45.446	£ 107.71	£ 180.00	£ 96.00	6.1 Years	3.0 Years
24 (2 per month)	90.893	£ 215.42	£ 180.00	£ 192.00	5.1 Years	2.5 Years

Figure 4. Savings and paybacks associated with replacing the oil bath and water cooled condenser system (electricity at £0.10/kWh, water at £2.37 per m3)

The paybacks shown in Figure 4 are only for one specific reaction. The same equipment would be used for other reactions, thereby generating further savings and lower payback periods. Alongside the savings in running costs, Dr Martinez-Martinez also highlighted the benefits he identified with using the Heat-On block with Findenser system (Figure 5).

Observation	Advantage Compared To Using The Oil Bath With Water Cooled Condenser
No Oil & Water	**Safety** - (1) Eliminates risk of spillages, which take time and money to clean. (2) No risk of hot oil splashes. (3) No danger caused by water leaking from the condenser into the oil bath . (4) No risk of flooding the laboratory. **Contamination** - (5) Eliminiates the risk of oil being contaminated which would result in an oil change (£90/change).
Temperature Control	**Stability & Safety** - Oil baths overshoot when warming to the set point temperature, which can be (1) dangerous and (2) have a negative effect upon the reaction.
Apparatus Support	**Safety** - The Heat-On block provides a stable base, which helps to secure and hold the complete system in place.
Insulation	**Stability** - The PTFE Heat-On block jacket insulates the reaction from air flow through the fume cupboard, maintaining a more stable temperature and assisting energy efficiency.

Figure 5. Advantages of Heat-On with Findenser system compared to existing oil bath with water cooled condenser system.

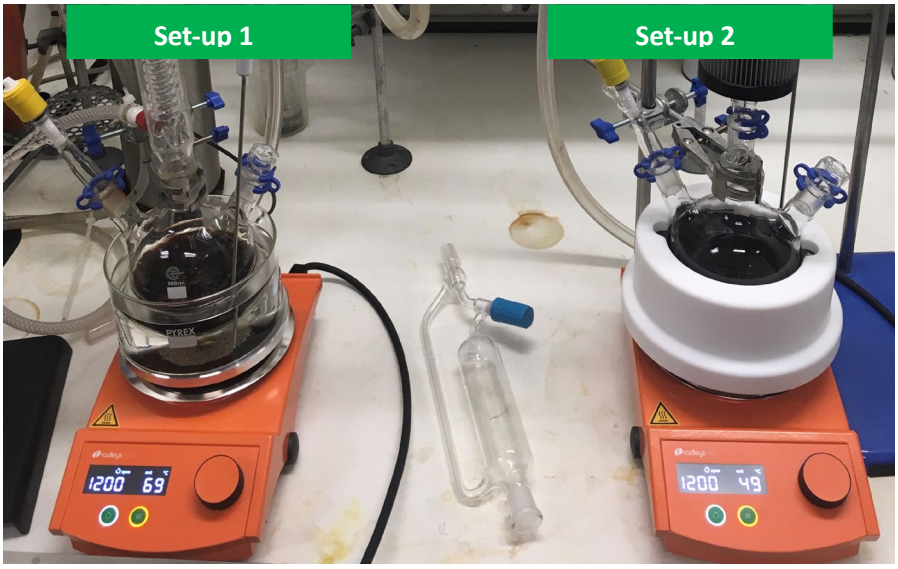

Figure 6. Oil bath system overshooting to 69°C (50°C set point).

The replacement of oil bath systems using water cooled condensers offer a variety of benefits to both the researcher and building management. The reductions in running costs not only reduce the burden upon building electricity and water costs but also upon the budget of the researcher. The researcher is also able to work in a safer working environment using a system which is easy to use over a wide range of reactions. The system used in this case study has an estimated lifespan of at least 10 years, ensuring that savings will be captured for many years after the calculated payback periods.

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