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Figure 1, Test setup.

Asynt Air Condenser Evaluation

Introduction

In our lab we usually use water condensers when running reactions at reflux temperatures. There are several well-known problems associated with these. First you need a water supply. This restricts the area where you can setup the reaction as well as the number of reactions you can conveniently setup in the same fume hood. Secondly there is the risk of a water leak. This risk increases when you are running multiple reactions in the same fume hood from the same water source. The tubing will also be in the way and make other work in the fume hood more difficult. A solution that has been suggested to solve both these problems is the use of air condensers. We were asked to evaluate the Asynt Air Condenser. We compared it to the water condensers from our lab as well as to a competing commercially available Air Condenser (brand A) and three air condensers that we assembled out of our lab equipment.

The condensers

Asynt Air Condenser (commercial)

The Asynt Air Condenser used in this test is 450 mm with B24 socket, figure 2. This condenser is entirely made of glass and very light. It has pigs that stop it from rolling when put on a table top. The only inconvenient factor is that it is very long. This makes it take up a lot of space in the fume hood.

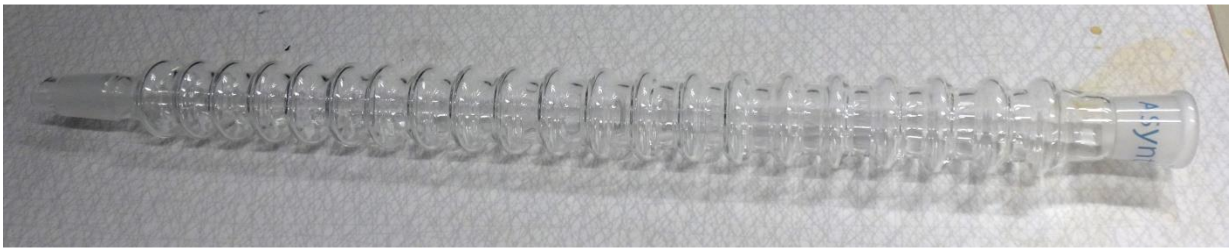

Figure 2, Asynt Air Condenser.

"Brand A" Competing Air Condenser

In this test we used Brand A with B24 Cone, B24 Socket. Note that it is stated on the Brand A homepage that the maximum flask size and solvent volume for the condenser tested is 250ml flask with maximum solvent volume 125ml. In this test we use a flask size of 500 ml and a solvent volume of 300 ml. This condenser is only 27 cm long so it does not take up a lot of space. However, it is very heavy. As it is made from additional materials to glass it cannot be dried in oven or by flame.

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Water condenser (the lab standard)

This is the standard condenser used in the lab, figure 3. It is made of glass and is connected either to the water taps or to the BMC cooling system. The cooling system is a closed circuit system with cooling liquid that makes it unnecessary to use tap water for cooling. This brings down the water cost and is also good for the environment. The problem with this system is that the pressure is very high. When attaching the condenser the tubes have to be secured by clamps. Exchanging the condenser is therefore very time-consuming. The high pressure also increases the risk of leaks. For these reasons the normal water taps are still in frequent use for the condensers used in the fume hoods.

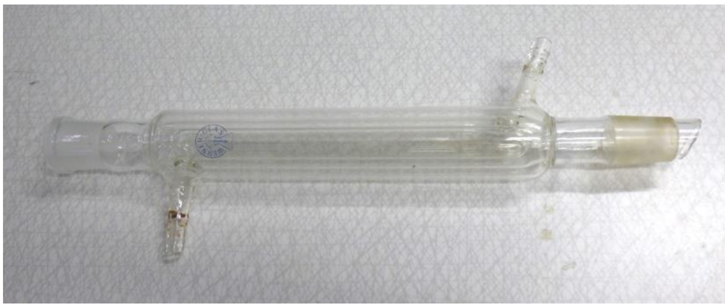

Figure 3, Standard water condenser.

Long straight condenser (improvised air condenser)

This is a normal simple water condenser with B24 socket, figure 4. At 470 mm it is as long as the Asynt Air Condenser and a lot longer than the Brand A condenser. The inside is an unbroken cylinder, making the surface area quite small. When used it was completely free of water and dry inside. Like the Asynt Air Condenser it is quite long and takes up a lot of space in the fume hood.

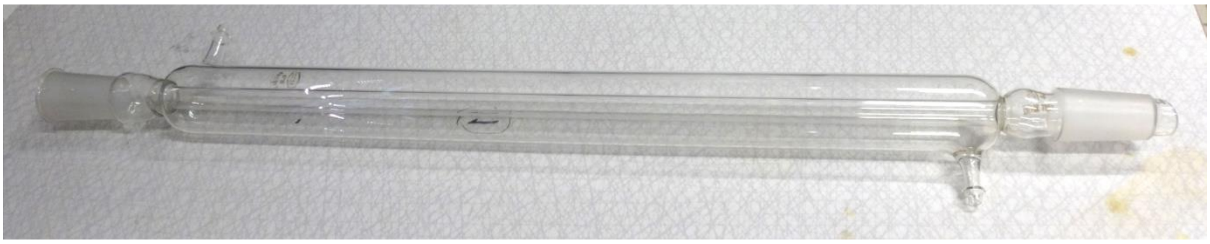

Figure 4, Long straight condenser.

Spiral condenser (improvised air condenser)

This is another regular water condenser with B24 socket, figure 5. The inside consists of two layers of spiralled hollow glass making the surface area very large. The condenser is 320 mm long and when it was used it was completely emptied of water. This is the normal size for the condensers we use so the handling was not affected other than the lack of tubing made the positioning easier and the fume hood less messy.

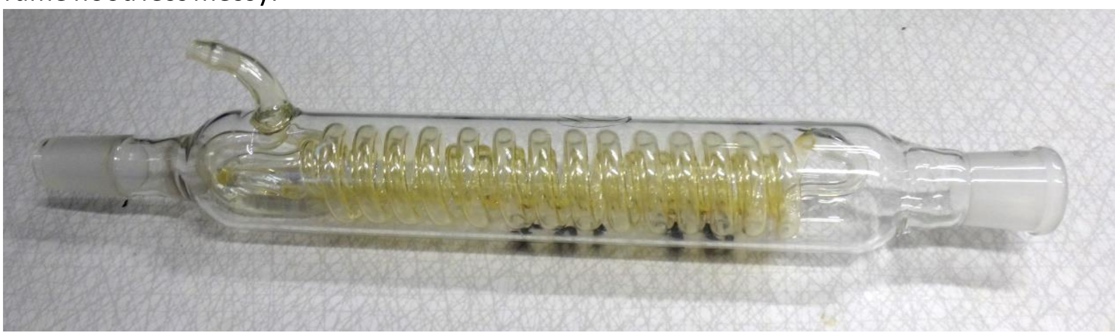

Figure 5, Spiral condenser.

Vigreux column condenser (improvised air condenser)

This condenser consists of a 280 mm vigreux column with a B19 socket and a connector with a B24 socket, figure 6. The extra joint increases the risk of leaks and this condenser is also shorter than the Asynt Air Condenser. This condenser is very small and light. As it is only one layer of glass it is very easy to dry and clean.

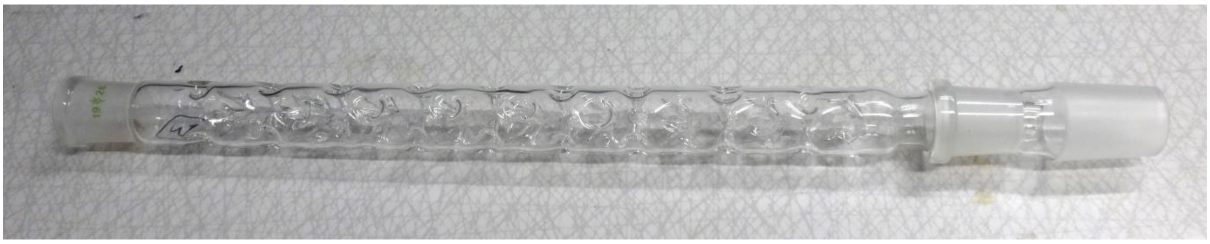

Figure 6, Vigreux column condenser.

Tests

All the tests were performed with 300 ml solvent in a 500 ml round bottomed flask. Thermostats were used to keep a stable temperature. The tests were run for 17 h overnight.

The solvents used in the tests are presented in table 1 along with the temperatures they were heated to. Thermostats were used in all tests.

Table 1, The solvents used in this investigation with boiling points and the temperature they were heated to during reflux.

Solvent	Boiling point (C°)	Heated to (C°)
DCM	39,6	46/51
Diethyl ether	34,6	40
Petroleum ether	40-60	65
Ethyl acetate	77,1	81

Solvent test

In the first test we compare how the commercial air condensers perform against the water condenser when refluxing some low to medium boiling point solvents. The solvents tested were DCM, diethyl ether, petroleum ether and ethyl acetate. The temperature was set to 5 C° above the boiling point.

Lab condenser test

After satisfying ourselves that air condensers actually work we wanted to see if the commercial condensers perform better than something we could assemble from our own glassware. In this test we repeated the DCM test with the long straight condenser, the spiral condenser and the vigreux column condenser.

Temperature test

As the temperatures in oil baths are not always so stable, especially if reactions are run without thermostat or if undergraduate students are involved, we wanted to try the performance of the condensers at a higher temperature setting. We repeated the DCM test with the temperature increased from 5 C° above the boiling point to 10 C° above the boiling point. This test was performed on the commercial air condensers and the best of our lab condensers.

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Results

Solvent test

In this tests the performance of the commercial condensers were tested on low to medium boiling point solvents. The results are presented in table 2. The water condenser is very reliable with all these solvents and only gives small losses. The Asynt Air condenser also performs very well in all these tests. The Brand A also performs reasonably well even though it is designed for smaller amounts of solvents.

Table 2, The loss of solvent over 17 h for the Asynt Air Condenser, the Brand A Condenser and the standard water condenser at a temperature set to 5 C° above the solvent boiling point.

Condenser	DCM (%)	Diethyl ether (%)	Petroleum ether (%)	Ethyl acetate (%)
Asynt Air Condenser	2,1	4,7	2,0	1,6
Brand A Air Coindenser	6,7	10,9	2,5	0,7
Water condenser (connected to tap water)	6	2,5	1,8	0,4

Lab condenser test

In this test we wanted to see if standard lab glassware used without cooling medium could work as well as commercial air condensers. The results are shown in table 3. The long straight condenser with small surface area was leaking a lot from the start. This shows that the commercial condensers cannot be substituted by just a glass tube of equal length. However, the spiral condenser and the vigreux column condenser both worked very well. Both had a high surface area but were notably smaller and lighter than the commercial air condensers.

Table 3, The loss of DCM over 17 h for the long straight condenser, the spiral condenser and the vigreux column condenser at a temperature set to 46 C°.

Condenser	DCM (%)
Long straight condenser	68,2
Spiral condenser	2,4
Vigreux column condenser	3,3

Temperature test

In this test we wanted to see how performance was affected by increasing the temperature to 10 C° above the boiling point. The results are presented in table 4. As can be seen neither condenser performed well. The condenser with the lowest loss was the Asynt Air Condenser at 36 %. The spiral lab condenser lost all solvent leaving the reflux system completely dry.

Table 4, The loss of DCM over 17 h for the Asynt Air Condenser, the Brand A Condenser and the spiral condenser at a temperature set to 51 C°.

Condenser	DCM (%)
Asynt Air Condenser	36,3
Brand A Air Condenser	66,1
Spiral condenser	100

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Conclusion

We have tested the Asynt Air condenser against a standard water condenser, a commercial competitor and some glassware from our lab. We can see that when refluxing overnight and keeping the temperature at 5 C^{o} above the boiling point of the solvent the commercial condensers work almost as well as a water condenser. In this test the Asynt Air condenser slightly outperformed the Brand A Air Condenser, but it should be noted that the Brand A condenser was designed for only half the amount of solvent we used in these tests. We could also see that at this temperature setting lab glassware with high surface area worked almost as well as the commercial air condensers.

When increasing the temperature to 10 C^{o} above the boiling point all the condensers tested leaked heavily. However, the Asynt Air condenser was the one performing the best with 36% loss of solvent over 17 h.

We conclude that temperatures and surface area are the deciding factors and that as long as the temperature can be properly controlled air condenses are a good option to water condensers. However, with proper control of temperature it seems that an air condenser might be assembled from standard lab equipment. If the temperature is not properly controlled (as for instance if no thermostats are available) a standard water condenser appears to be the safest option.