

From causes the
double bonds to
break.



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From the calculations obtained, the yield of extracted oil was not expected as it surpasses the expected yield of 11.3% (1/8.

83 x 100%), this could be due to the extraction process. Water was extracted as well as limonene therefore resulted in additional mass of extracted oil causing a higher yield of orange oil. Following the results in the three test tubes containing R-Limonene, Cyclohexane and Cyclohexene, Bromine water reacted differently with each component. First and foremost, Bromine are electrophiles as they are attracted to electron rich regions, (Clark, 2015) they are very polarisable, meaning they undergo electrophilic addition reaction with ethenes forming pi-complexes. Even though ethenes are non-polar molecules, they contain an area of high electron density around the carbon-carbon double bond. This makes ethene a target for electrophile attacks. In Test Tube 1, Limonene is added to the bromine water and the bromine water turns colourless. This is because carbon-carbon double bonds are present in limonene and this creates an electrophilic reaction between the bromine in the bromine water and limonene.

As the bromine molecule approaches the pi bonds of the limonene, an induced dipole is formed within the bromine molecule, (Clark, 2000) the electrons in the bonds are pushed to one end resulting in a positively charged bromine and a negatively charged bromine. The negatively charged bromine atom repels from the pi bond and automatically lines up the right way around for a successful attack on the ethene whereas the positively charged bromine atom (nearer to the pi bonds) becomes attached to both carbon atoms and this causes the double bonds to break. (Clark, 2000) Sigma bonds are formed between the two carbon atoms of the alkene and the positively charged

bromine, and this leads to the formation of a cyclic bromonium ion. This bromonium ion is then attacked by the negatively charged bromine atom from the back-side in relation to the transition state of the nucleophilic reaction, this once again breaks the bromonium bond and forms a haloalkane. Limonene has 2 double bonds therefore 2 bromine atoms will attach to each resulting in the formation of 4 bromine atoms.

Since the brown colour comes from the elemental bromine, when the saturation of bromine decreases, the brown colour decreases and eventually turns colourless. In Test Tube 2, A layer of brown oil surfaced to the top, this brown layer consists of bromine and cyclohexane. Bromine in the bromine water is more soluble in cyclohexane than in water (Clark, 2015) therefore it transfers into the cyclohexane layer, leaving the water.

Bromine is non-polar therefore it is much more soluble in organic solvents such as hexane than in water, this is due to the fact that both of them are non-polar molecules therefore they are attracted to each other by Van der Waals forces. However, the bromine water does not decolourise, this is because cyclohexane does not contain a C-C double bond therefore a pi complex does not occur. In Test Tube 3, The bromine water becomes colourless after three drops of cyclohexene is added. This is because cyclohexene contains double bonds and bromine itself is very reactive therefore it attaches itself to the double bonds. As it approaches the unsaturated bonds, the bonds between the bromine ions become polarized by the electron rich pi cloud of the carbon-carbon double bond. The positively charged bromine attacks the pi bond of the cyclohexene and the carbon-carbon double bond breaks, new single bonds are formed from each of the

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carbon atoms in which attaches to the bromine ions and a bromonium ion is formed. The bromonium ion is then attacked from the back (Clark, 2003) by a nearby bromide ion and this causes the bromine to lose its original reddish-brown colour, giving out a clear and colourless liquid. (Clark, 2000).

Besides bromine water, another way to characterise the extracted oil is by using potassium manganate (VII). Potassium manganate (VII) are strong oxidising agents, (Clark, 2016) therefore alkenes (limonene) can be oxidised by it. The products formed varies on the conditions chosen for the reaction. Under acidic conditions, potassium manganate (VII) with dilute sulphuric acid. When added to alkene in a dilute solution, the colour changes from a pale purple to colourless and alkene is converted into a diol. If sodium carbonate solution is added to potassium manganate (VII), it becomes slightly alkaline.

The purple manganate (VII) ions are reduced to green manganate (VI) ions and eventually becomes a dark brown solid manganese (IV) oxide. (Clark, 2016). These two methods prove that the extracted oil contains C-C double bonds as both end products contain two alcohol groups (-OH), alkene is oxidised into alcohol.