CHEMISTRY

The Sulfate Content of a Fertiliser

❖ ***Aim***

To use gravimetric analysis to determine the sulfate content of a lawn fertiliser

❖ ***Hypothesis***

The sulfate content of the fertiliser will be found to be 17.5%, the percentage composition indicated by the contents label of the sample.

❖ ***Method***

1. 0.63 g of the powdered lawn fertiliser was accurately weighed out and transferred to a 250mL beaker. 25mL of warm water was subsequently added to the beaker and the contents were stirred with a glass rod, dissolving the fertiliser crystals.
2. Safety glasses were worn as 10 drops of concentrated hydrochloric acid was added to the solution.
3. The mixture was heated on a hotplate until the moment it began to boil.
4. A burette was utilized to further add 7% barium chloride solution to the hot mixture in excess.
5. The mixture was then re-boiled on the hotplate to coagulate the white precipitate, and then allowed to stand and cool for a further 5-10 minutes.
6. A circle of quantitative filter paper and a clock glass were weighed on an electric balance, and their weight recorded.
7. The filter paper was set up with a filter and a retort stand, and a clean beaker placed underneath. The cooled mixture (from step 5) was carefully poured through the filter, and all the barium sulfate precipitate was transferred from the beaker to the filter by using small amounts of warm distilled water.
8. Once the filtration process was complete, the filter paper was transferred to the clock glass and allowed to completely dry in the dessicator.
9. The clock glass, filter paper and dried barium sulfate were consequently weighed.

❖ Results

Table 1:

	Mass (g)
Fertiliser	0.63
Clock glass and filter paper	24.80
Clock glass, filter paper and $BaSO_4$ precipitate	25.70
$BaSO_4$	0.90

Calculations:

$M_{(BaSO4)}$=233.37gmol^{-1}

$M_{(SO4)}$=96.07gmol^{-1}

∴ $SO_4^{2-}{}_{(mass\ of\ BaSO4)}$=0.370497493…

And 0.63g of fertiliser contains 0.37…g of sulfates.

∴ $SO_4^{2-}{}_{(\%\ by\ mass\ of\ fertiliser)}$ = 58.81% (2.d.p)

❖ Discussion

The given experimental value for the percentage composition of SO_4^{2-} in fertiliser, 58.81%, is much higher than the actual 17.5% value indicated by the contents label of the sample. The experimental error of 236.06% can be attributed to the invalid experimental method. Firstly, the derivation of the value of total mass of sulfates in the fertiliser relies upon precipitating the sulfates out of the fertiliser solution. The initially solid fertiliser dissociates in solution with the addition of the warm water, so that the addition of the barium chloride solution results in the formation of insoluble barium sulfate precipitate:

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \leftrightarrow BaSO_4(s)$$

However, lawn fertiliser contains phosphates as well, which also combine with barium to form an insoluble solid which precipitates out of solution:

$$Ba^{2+}(aq) + PO_4^{3-}(aq) \leftrightarrow Ba_3(PO_4)_2(s)$$

This precipitate has a high molecular weight of 601.84gmol^{-1} which, when mistakenly included in mass calculations as a sulfate, would obviously render the results highly inaccurate. Secondly, other anions were also present in the fertiliser solution, and any of these could also have adhered to the sulfate and been mistakenly included in the gravimetric analysis calculations. Lastly, any barium

chloride solution which was improperly filtrated and adhered to the surface of the precipitate would have crystallized in the dessicator and hence further contributed to the higher mass value.

The experimental method does, however, have some merits. The addition of hydrochloric acid, for example, ensures no carbonate ions are present which would interfere with the gravimetric analysis of the sulfates. Further, the coagulation of the precipitate prevents it from passing through the filtration process and the washing of the filtrate removes other adhering ions. The drying of the filtrate in a dessicator is also one effective way of removing some of the remaining solution which would otherwise affect the results. The employment of an accurate balance also improves the reliability of the results.

The experimental method could be improved through a number of ways. A fertiliser comprised of only sulfates and nitrates is preferable, since the nitrates will not precipitate out of solution upon the addition of any other solution (all nitrates are soluble). Also, the powdered fertiliser should be completely dissolved in water to ensure all sulfates are removed from the sample with the precipitate, rather than having solid 'grit' remain. This could be achieved by using water of a higher temperature to increase the solubility of the fertiliser. The solubility of barium sulfate should be more thoroughly researched by students prior to the commencement of the experiment, to ensure the barium chloride actually is 'in excess'. The limited visibility caused by the cloudiness of the solution upon the formation of the barium sulfate precipitate made it impossible to discern when the solution had become saturated, and students simply guessed when enough barium chloride has been added. The experiment could also be improved by repetition of the method and the comparison of individual results between groups to obtain a class average.

Gravimetric analysis is nonetheless a method which is highly scientifically significant in society. When used effectively, it is particularly important in determining the exact percentage composition of items such as food, or in this case, fertiliser, so that producers can meet the stringent labeling laws of their particular industry.

❖ ***Conclusion***

The hypothesis has been rejected. The sulfate content of the fertiliser was inaccurately found to be 58.81% rather than 17.5%, due to an invalid experimental method.