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## GRAVIMETRIC ANALYSIS OF MAGNESIUM IN PHARMACEUTICAL SUBSTANCES

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**Summary:** The aim of this study was to determine the content of magnesium in magnesium-chloride and magnesium-sulfate using the gravimetric analysis method, and to do the comparison of experimental results with calculations, stoichiometric calculation. Magnesium is one of the least present minerals in the soil and that is why, even in a well-balanced diet, a lack of magnesium is present. It is of great importance for the human body and is increasingly consumed using different nutritional supplements. Magnesium-chloride is one of the best forms for the compensation magnesium in the body, because the body absorbs it the best.

**Keywords:** gravimetric method of analysis, magnesium, magnesium-chloride

### Introduction

Gravimetric analysis is the subject of research and application of every analyst because of the simplicity, economic accessibility and accuracy. The result gravimetric analysis is always visible, the mass is the primary physical property of substances, excluding secondary or indirect effects of physical and chemical methods of analysis, which may lead to wrong conclusions. When performing gravimetric analysis it is necessary to separate the component that is being determined in the form of a pure phase from the other components of the sample. This stage can be a determined component or some compound that can be easily converted to a form of a known and constant chemical composition that is suitable for measuring mass.

Most widely used methods of execution of gravimetric analysis are sludge methods. With sludge methods it is very important to make a careful selection of the precipitated reagent. The ideal precipitated reagent for gravimetric analysis should react specifically or at least selectively with a determined substance (Vindakijević & Sladojević, 2005).

The application of gravimetric analysis methods in practice in this paper is shown through the gravimetric determination of magnesium in pharmaceutical substances. After the completion of gravimetric analysis as a result is a substance isolated from the compound that is visible, measurable, tangible, and that provides the basic features to the compound.

Magnesium is a natural mineral for which there is no substitute. Because of the use of fertilizers and pesticides it is less and less present in food. Disturbing the natural soil composition, it deprives us of essential minerals such as magnesium. Modern food is refined, up to 99% of magnesium is removed from the food. Therefore, those who try to follow a well balanced diet probably have a lack of iodine in the body, and its role is large (Coates et al., 2010).

Magnesium is a cofactor in over 325 enzyme systems that regulate basic biochemical reactions in the body, including protein synthesis, muscle synthesis and nerve function synthesis, blood sugar control and regulation of blood pressure (Watkins & Josling, 2010) (Coates et al., 2010) (Ross et al., 2012). Magnesium is necessary for energy production, oxidative phosphorylation and glycolysis. It contributes to the

development of structural bones and is required for the synthesis of DNA and RNA. Magnesium also plays an important role in the active transport of calcium and potassium ions across the cell membrane, a process important for conducting nerve impulses, muscle contraction and normal heart rhythm (Ross et al., 2012).

A needed daily dose of magnesium is 300 to 400 mg. The body of an adult contains about 25g of magnesium, of which 50-60% is present in the bones, and the rest mainly in the soft tissues (Erdman, Macdonald & Zeisel, 2012).

Magnesium is widely used in food and drink. Green leafy vegetables such as spinach, legumes, nuts, seeds and whole grains are good sources of magnesium. In general, foods that contain fiber provides magnesium. Minerals are in contrast to vitamin more resilient-remain in food after frying and steaming. However, although it is not easily disintegrate, they need to be introduced into the body. One of the most common reasons for higher magnesium deficiency is inadequate and poor quality food (diet) (Coates et al., 2010).

The body mostly absorbs approximately 30-40% of magnesium consumed in the diet (Coates et al., 2010). However, considering that all the food is poorer in minerals, including magnesium, every day interest is increasingly paid to the use of magnesium supplements in the daily diet.

Magnesium supplements are available in a variety of forms, including magnesium oxide, citrate, chloride. Absorption of magnesium from different types of magnesium supplements varies. Forms of magnesium that is well dissolved in the liquid is almost completely absorbed in the gut (Ranade & Schomberg, 2001). Tests Firoz and Graber (2001) have shown that the magnesium chloride is much better absorbed than the bioavailable magnesium oxide or sulphate, and that very high doses of zinc supplements (142mg/day) interferes with the absorption of magnesium and disrupts his balance in the body. Research Lindbergh, Zombitza, Poindexter and Pak (1990), and Shechter et al. (2012) have shown that the oral use of magnesium oxide gives better results when following levels of total cholesterol and LDL cholesterol, compared to magnesium citrate, whereas in healthy subjects heart disease does not occur.

Oral use of magnesium is a growing challenge for many individuals, who seek an effective return of intercellular levels of magnesium. However, care should be taken about ionised magnesium used. Work Wetkinsa & Josling (2010) showed that magnesium oxide, inexpensive magnesium complex, a popular dietary supplement, subject to the absorption of only 4%. If we consider that the recommended daily intake of magnesium 300-400mg of elemental magnesium per day, that would mean that by magnesium oxide a useful dose would be only 12-16mg. Even magnesium citrate, which is relatively well absorbed, provides the absorption rate of up to 50%. And yet, the real rate of absorption of magnesium from its supplements is rarely taken into account. Therefore, the use of magnesium in the form of its chloride salt is a simple and effective methodology for increasing the level of magnesium and establishing balance with calcium in a positive way.

Magnesium chloride as many scholars have recognized as “major magnesium compound” for dietary for local use. Dean (2007) explained that the magnesium chloride and other inorganic magnesium salts appear as metal-binding (metal-ligand) complexes, substances linked around a central metal atom, in this case magnesium. Each of these metal-binding substances can be joined the “stability constant” that determines their relative ability to migrate in an ionic form. With regard to the forms of magnesium supplements, the bioavailability of substances is greater the stability constant is closer to zero (Table 1). It is of great importance, because the body does not absorb magnesium in the form of magnesium chloride, but as free magnesium and chlorine ions.

**Table 1.** Values stability constants for some common magnesium compounds (Dean, 2007)

Magnesium compounds	Stability constant	Ionised
Magnesium chloride	0	Totally ionised
Magnesium acetate	0,51	Mostly ionised
Magnesium gluconate	0,70	Mostly ionised
Magnesium glutamate	1,90	Mostly ionised, but neurotoxic
Magnesium citrate	2,80	Mostly ionised

The ability of magnesium chloride is clearly seen in the following table. On the stability constant equal to zero, magnesium chloride is completely ionized in a wide range of pH, from the low pH 2-3, which is located in the gastric acid and to slightly based saline pH 7,4, which is located in the extracellular fluids (Dean 2007).

The symptoms caused by a lack of magnesium in the body in healthy people are not expressed because the kidneys are limiting the excretion of minerals. However, low intake or excessive loss of magnesium due to certain health problems can lead to the emergence of a variety of disorders. Early signs of magnesium deficiency include loss of appetite, nausea, vomiting, fatigue, and weakness. Typically low magnesium intake causes biochemical changes in the system, which over time increases the risk of various diseases (hypertension, diabetes, osteoporosis, migraine). That is why today there is a growing interest for the role of magnesium in preventing and managing disorders such as hypertension, cardiovascular disease and diabetes (Saris et al., 2000) (Rajaković et al., 2004) (Kass, Skinner & Poeira, 2013).

Coates (2010) is already in the initial analysis found that magnesium supplements have a positive effect for hearing impairment as with sudden hearing loss in adults.

Excess magnesium from food does not pose a risk to the health of a healthy person because the kidneys expell excess magnesium in the urine (Musso, 2009).

## Materials and Methods

Samples used in the gravimetric determination are:

**Table 2.** Magnesium chloride, hexahydrate ( $MgCl_2 \times$  magnesium sulfate, heptahydrate ( $MgSO_4 \times$

Scaling	$Mg_2P_2O_7$ ( g ) ( of $MgSO_4 \cdot 7H_2O$ )	$Mg_2P_2O_7$ ( g ) ( of $MgCl_2 \cdot 6H_2O$ )
$m_1$	0.1417	0.1230
$m_2$	0.1395	0.1245
$m_3$	0.1389	0.1203
$m_{sr}$	0.1400	0.1226

Aliquot part of the determination of Mg is 50 ml

With the statistical calculation of the t-test ( $t=0.0024 < t_{(3; 0.05)}=3.18$ ) it was found that the difference in the masses of sediment  $Mg_2P_2O_7$  obtained from different samples is not statistically significant.

Calculation of results obtained from gravimetric analysis is simplified using the gravimetric factor F, whose values can be calculated or are found in the corresponding tables, which is the stoichiometric ratio of the molar mass of the required ingredient (required form) and the molar mass of the measured ingredient (measured form) (Vindakijević & Sladojević, 2005). The term gravimetric factor substances studied in this work is shown in Table 3.

**Table 3.** The formula for calculating the gravimetric factor Mg

Measured substance	Asking substance	The gravimetric factor (F)
$Mg_2P_2O_7$	Mg	$F_{Mg} = \frac{2M_{Mg}}{M_{Mg_2P_2O_7}}$

Multiplying the mass of annealed sediment with gravimetric factor, the mass of the required substance is obtained. Comparison of the results obtained by stoichiometric calculations, and gravimetric analysis is shown in Table 4.

**Table 4.** The masses of the analyzed substances obtained from stoichiometric and gravimetric analysis

Asking substance	Stoichiometry (g)	Gravimetry (g)	Deviation (%)
Mg ( of $MgSO_4 \times$	6.0763	6.0200	0.8
Mg ( of $MgCl_2 \cdot 6 H_2O$ )	5.9632	5.3000	11.1

For clarity of results, values are expressed in 1 l of the prepared sample

Based on the results shown in Table 4 the Mg content is calculated in the corresponding salts that are used as samples in this experiment. The results are shown in Table 5.

**Table 5.** Mass of the required substances expressed per 100 g of sample

Asking substance	Stoichiometry (g)	Gravimetry (g)
Mg ( of $MgSO_4 \times$	9.8640	9.78501
Mg ( of $MgCl_2 \cdot 6 H_2O$ )	11.7161	10.4156

With the statistical calculation of the t-test ( $t=0.2307 < t_{(2;10.05)}=4.30$ ) it was found that the difference in the obtained stoichiometric and gravimetric results of the analyzed samples is not statistically significant.

Comparing the results obtained gravimetrically and stoichiometrically deviations were calculated, that are for magnesium in epsom salts is 0.8%. Such deviation is minimal, and it can certainly be argued that the applied method of gravimetric analysis is suitable for the determination of magnesium in the sample of epsom salts.

During the designation of magnesium in the sample of magnesium chloride hexahydrate, during annealing precipitates were obtained whose mass from parallel analysis show minimal deviation (confirmed by matching the values of the first two decimal places). However, after stoichiometric calculations, it was shown that the gravimetric analysis shows significantly lower magnesium content in the analyzed samples by 11.1%.

## Conclusion

- Gravimetry as a method of quantitative chemical analysis, has been replaced by other methods that enable us to more quickly and easily get the desired results. Gravimetric analysis methods allow analysis of only one or a limited number of elements. However, one should not forget the great advantage of this method, which is different from the others and makes it indispensable in this regard, and that is its **great accuracy and precision**.

- In this study obtained results were compared to stoichiometric and gravimetric analysis, whilst with

gravimetric analysis less masses were obtained. Based on this we can conclude that during gravimetric analysis there was no contamination of sediments in any of the samples analyzed, and the gravimetric analysis method is suitable for the determination of magnesium contents in tested pharmaceutical substances.

- Deviations of experimental data with respect to the stoichiometric calculation, which is related to the content of magnesium in the bitter salt, are insignificant and amounted to 0.8%.
- Deviation obtained in determining the magnesium from magnesium chloride hexahydrate is significant and amounts to 11.1%.

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