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Investigation of Vapor Pressure and Infrared Spectroscopic Analysis of Phosphoric Acid Extract Evaporation after Desulfation with $SrCO_3$

Ammophos-Maxam JSC is renowned for the production highly concentrated phosphorus fertilizers such as ammophos, ammonium sulfate phosphate, and suprephos, using thermally concentrated phosphorites sourced from the Central Kyzylkums. The production process heavily relies on wet-process phosphoric acid (WPA), which typically contains 16–18 % phosphorus pentoxide (P_2O_5). However, converting low P_2O_5 WPA into these high-phosphorus fertilizers during the stages of evaporation, drying, and granulation stages significantly increases the heat and energy consumption per unit of the final product. To address these challenges, extensive initiatives are currently underway in the republic. These efforts are aimed at improving the production of various phosphorus fertilizers, including ammophos, suprephos-NS, ammonium sulfate phosphate, PS-Agro, enriched superphosphate, and feed ammonium phosphates. These products are derived from the processing of washed burnt phosphoconcentrate (WBP-26) obtained from Kyzylkum phosphorites. This paper describes the results of recent studies on the evaporation process of WPA at Ammophos-Maxam JSC. The research focuses on examining the boiling point of WPA solutions, vapor pressure, and the composition of the resulting precipitates. Additionally, infrared (IR) spectroscopy was conducted to provide deeper insights into the material properties. These investigations are crucial for optimizing production processes and reduce energy costs.

Keywords: phosphorus, wet process phosphoric acid (WPA), Central Kyzylkums, ammophos, superphosphate, fertilizers, feed phosphates, IR spectroscopy.

Introduction

Simultaneously, the field of animal husbandry has long sought innovative solutions, particularly in the realm of feed additives for farm animals. This pursuit reflects the adaptability of the agricultural sector to the changing demands and challenges of modern practices. One notable example is the exploration and incorporation of advanced nutritional supplements for farm animals to optimize their health, productivity, and overall welfare. This concerted effort underscores the commitment of farmers to embrace new technologies and practices, contributing to the resilience and sustainability of global agriculture amid the complexities of contemporary agro-industrial dynamics.

The global demand for Mono and Diammonium Phosphates (MAP and DAP) [1, 2], as well as Nitrogen-Phosphorus (NP) and Nitrogen-Phosphorus-Potassium (NPK) fertilizers, underscores their pivotal role in modern agriculture. The production of these fertilizers relies exclusively on concentrated phosphoric acid. Consequently, the imperative task at hand is the advancement of technology for the concentration of WPA, aiming to achieve the production of high-quality phosphorus-containing fertilizers. At the same time, the Republic is actively engaged in the development of functional feed additives for animal husbandry, where domestic products are progressively competing with their foreign counterparts. In order to meet these challenges, it becomes essential to substantiate pertinent scientific solutions in several key areas. Firstly, the identification optimal conditions for desulfurizing weak WPA is a foundational step. Subsequently, the concentration of desulfurized WPA through evaporation must be refined to ensure efficiency. Concurrently, efforts are directed towards enhancing the rheological characteristics of evaporated WPA, a critical aspect of the production process. Lastly, the development of technology for various grades of ammonium phosphates, complex fertilizers, and feed additives derived from concentrated WPA requires meticulous attention. This multifaceted approach not only meets the urgency of the task at hand but also positions the domestic industry on a competitive front against foreign counterparts in the dynamic landscape of fertilizer and feed additive production.

In the production processes of double superphosphate, ammophos, nitroammophos, and liquid fertilizers at chemical plants, a concentrated phosphoric acid solution, referred to as WPA, plays a crucial role. The concentration of this solution is carefully adjusted according to the specific fertilizer being produced. For double superphosphate and ammophos, the WPA concentration falls within the range of 45–55 % P_2O_5, while a higher concentration of 72–83 % P_2O_5 is utilized for ammonium polyphosphates and liquid fertilizers [3–5]. To achieve higher concentrations, the WPA is evaporated, reducing its water content and thereby increasing the concentration of phosphorus pentoxide (P_2O_5). The evaporation process theoretically allows for the production of solutions with exceptionally high P_2O_5 concentrations, as the steam produced from pure H_3PO_4 consists entirely of water. This highlights the advanced technological processes involved in crafting various phosphorus-based fertilizers, enabling the synthesis of products with diverse P_2O_5 concentrations to meet the specific needs of agricultural practices [6].

The scientific and technical literature provides valuable insights [7–11] into the prospect of producing evaporated WPA from the thermal concentrate derived from Kyzylkum phosphorite, and the subsequent formulation of liquid complex fertilizers. However, it must be recognized that the composition of WPA originating from thermal concentrate diverges from that produced at JSC Ammophos-Maxam, where washed burnt phosphoconcentrate (WBP–26) serves as the primary source. The distinctive chemical composition of WPA, particularly in terms of impurities such as MgO, Fe_2O_3, Al_2O_3, CaO and SO_3, is of considerable significance. These impurities possess the potential to exert a notable influence on both the evaporation process and the rheological characteristics of the resulting evaporated phosphoric acids. Consequently, a nuanced understanding of these variations becomes pivotal in optimizing the production processes and ensuring the desired rheological attributes of the evaporated phosphoric acids in the context of diverse phosphorite sources and processing techniques.

As sulfate ions constitute the primary impurity in WPA, the pivotal purification step should focus on desulfurization.

In a previous study by the authors [12], desulfurization of WPA with a composition as described above was conducted using $Ca(OH)_2$ and $CaCO_3$, employing WBP–26, containing up to 20 % CaO_{dig}. Subsequently, for further purification of the desulfurized WPA, a treatment with acetone (99.5 % C_3H_6O) was employed with a three-fold excess. However, despite the utilization of calcium-based substances and WBP–26, complete removal of sulfate ions was not achieved, with the removal rate not exceeding 85 %.

To overcome this limitation, the authors propose a more effective method involving the use of strontium salts [13] for the deepest desulfurization. The main technological advantage associated with strontium salts is their ability to significantly reduce the residual SO_4^{2-} content in the WPA solution, achieving a remarkable reduction by 30–40 times. This approach represents a promising avenue for enhanced desulfurization, addressing the challenges encountered with conventional calcium-based substances and offering a more comprehensive solution for sulfate ion removal in the processing of WPA.

The article describes the key applications of infrared (IR) spectroscopy in the examination of sediments derived from the initial desulfurized and the precipitation of evaporated WPA. Recognized as one of the most efficient spectroscopic techniques for chemical analysis, IR spectroscopy boasts exceptional capabilities in providing valuable qualitative insights into the composition of substances. However, it is acknowledged that its precision in quantitatively determining compounds is comparatively modest. In chemistry, IR spectroscopy is mainly used for the qualitative determination of compounds. Regardless of molecular structure, functional groups within molecules exhibit absorption lines at specific wavenumber values, known as characteristic wave frequencies. These characteristic frequencies serve as informative markers, providing valuable insights into the nature of the analyzed substance. The vibrational spectrum, with its high-quality information, is considered a unique physical property of a substance. Consequently, infrared (IR) spectra are widely used to identify chemical compounds and mixtures within individual compounds. Additionally, the technique proves invaluable in studying the mechanisms of chemical reactions, further cementing its significance in the comprehensive understanding of chemical phenomena [14].

Experimental

The evaporation process of WPA from the current production at Ammophos-Maxam was systematically investigated in the laboratory. The WPA under examination exhibited the following composition by weight: P_2O_5 18.95; CaO 0.27; MgO 0.26; Fe_2O_3 0.41; Al_2O_3 0.56; F 0.45; $SO_{3tot.}$ 2.96 and $SO_{3dig.}$ 0.15. A notable deviation from conventional practices was introduced in the desulfurization step, where strontium salt replaced calcium minerals. The desulfurization process involved the utilization of strontium carbonate, specifically the “chemically pure” grade (minimum 98 % $SrCO_3$). This substitution was made owing to the strontium salt's proven efficacy in purifying phosphoric acid from sulfate ions. Furthermore, during the subsequent evaporation process of desulfurized phosphoric acid, achieving concentrations of 45–60 % phosphorus oxide (V), an additional purification step was observed, effectively eliminating other impurities from the acid. These distinctive features, namely the utilization of strontium salt during desulfurization and the consequential evaporation process, highlight the experiment's unique qualities. The incorporation of these innovative steps in the laboratory study showcases a deliberate approach to enhance the purity and quality of phosphoric acid, thereby contributing to the advancement of the production processes at Ammophos-Maxam. Experiments on the purification of WPA using $SrCO_3$ were conducted three times, and the average mean was calculated. A long with this standard deviation (SD), confidential interval (CI) and p-level of significance was noted to be 0.05. Based on them corresponding Student coefficient was used. The calculation was performed using MS Excel (Windows 10) with a 95 % confidence level (P = 95 %) and preliminary standard deviation (S) estimation based on a sample size of n = 3–4 [15].

Concentrated solutions were obtained through the evaporation of desulfated acid, and their chemical composition was meticulously assessed using various analytical techniques. The determination of P_2O_5 content was conducted through photocolorimetric methods, while SO_3 levels were quantified gravimetrically, and F-content was assessed potentiometrically. Calcium and magnesium content were ascertained via the complexometric method, where the change in color of the indicator (fluorexone for calcium and dark blue acid chromium for magnesium) induced by Trilon B played a crucial role. Sulfate content was determined gravimetrically by inducing sulfate precipitation through the addition of barium chloride in an acidic environment, followed by measuring the weight of the resulting sediment. The complexometric method was applied to determine iron and aluminum oxide levels. Specifically, 0.0125 M iron was titrated with Trilon B solution in the presence of sulfosalicylic acid, followed by the back titration of excess Trilon B using a 0.0125 M zinc sulfate solution. This complex procedure allowed the determination of aluminum content in the presence of a xylene orange indicator. Furthermore, the density of solutions was also determined using pycnometric methods, and the kinematic viscosity was ascertained using viscometric techniques. These analytical methods collectively contribute to a comprehensive understanding of the chemical composition and properties of the concentrated solutions obtained from the evaporation of desulfated acid.

The relationship between temperature and saturated vapor pressure is expressed by the equation:

$$\lg P = A - B / T .$$

In Table 1, there are data with Vapor pressure (kPa) at temperature (K), approximation equation and coefficients of determination (R^2).

As shown that vapor pressure increases as temperature rising but vapor pressure decreases with increasing WPA concentration. Approximation equation and Coefficients of determination (R^2) were calculated according to calculation Excel 2019. The confidence interval was 95 %.

According to their respective concentrations, the relationships between temperature (T) and saturated vapor pressure (P) for WPA are expressed by the following equations given in Table 1.

The reported values of the coefficient of determination R^2 are in the range of 0.9746–0.9995 meaning that the approximation equations fit the actual data quite well. Significantly higher R^2 values nearer to 1 as WPA (50.01 %, 55.25 %, and 60.34 %) show better fitness of the model that is able to predict almost all the fluctuations in vapor pressure data.

These equations provide a mathematical description of the temperature-dependent behavior of saturated vapor pressure for varying concentrations of phosphoric acid solutions. They play a crucial role in understanding the thermodynamic characteristics of the evaporation process for different WPA compositions.

Table 1

Vapor pressure of desulfated evaporated phosphoric acid

WPA concentration, P_2O_5, %	$\lg P = A – B/T$	Vapor pressure (kPa) at temperature (K)					Approximation equation	Coefficients of determination (R^2)	MSE (kPa²)	RMSE (kPa)
		293	303	313	323	333				
45.62	$\lg P = 5.1838 – 979.5/T$	7.56	11.98	15.09	18.98	23.37	$y = 8E\text{-}21x^{8.5179}$	0.9746	11483.45	107.16
50.01	$\lg P = 5.5457 – 1150.6/T$	5.63	7.59	9.78	12.9	16.24	$y = 2E\text{-}20x^{8.2849}$	0.9993	5230.13	72.32
55.25	$\lg P = 5.6590 – 1210.5/T$	4.5	6.22	8.39	10.81	13.93	$y = 9E\text{-}22x^{8.7995}$	0.9985	3744.12	61.19
60.34	$\lg P = 5.6399 – 1263.5/T$	2.85	3.93	5.43	7.16	9.44	$y = 2E\text{-}23x^{9.3674}$	0.9995	1603.53	40.04

IR spectroscopic analysis was conducted using a Perkin-Elmer FT-IR Spectrum 3 spectrophotometer [16], covering a frequency range of 4000–400 cm^{-1}. The acquired spectral data were validated by careful comparison with specific and authenticated reference sources. This rigorous authentication process ensures the reliability and accuracy of the obtained IR spectroscopic results, underscoring the integrity of the analytical methodology employed in this study

Results and Discussion

The optimum dosage of strontium carbonate for the formation of strontium sulfate was determined to be 100 % of the stoichiometry. In the procedure, the initial WPA was introduced into a reactor equipped with a screw stirrer and gradually heated up to 75 °C within a water thermostat. Subsequently, a calculated quantity of strontium carbonate powder was gradually added to the WPA over a 30-minute period, with continuous stirring. Following this dosing phase, the reactor contents were allowed to settle for 60 minutes at 60–65 °C. After settling, the desulfurized WPA was separated from the sediment through filtration, dried, and then weighed. The clarified portion, comprising the desulfurized WPA and its sediment, underwent analysis for the total content of SO_3 and P_2O_5 using established methods [17]. Based on the acquired data, the degree of desulfurization of WPA was calculated, and the results are presented in Table 2. This methodical approach ensures a systematic and comprehensive evaluation of the desulfurization efficiency in the context of varying strontium carbonate dosages.

Table 2

The degree of desulfurization of extraction phosphoric acid depending on the rate of strontium carbonate*

The $SrCO_3$ norm, %	$WPA_{desulfated}$, % (± Confidence interval with Student's distribution in α = 0.05)		P_2O_5 content in dry sediment, %	Desulphurization degree, %
	P_2O_5	SO_3		
95	20.86±0.41	0.15±0.16	0.71±0.80	96.17±0.20
97.5	20.86± 0.41	0.13±0.06	0.73±0.75	96.48±0.21
100	20.53±0.30	0.10±0.03	0.79±0.72	97.34±0.23
102.5	21.04±0.19	0.10±0.03	0.82±0.74	97.36±0.30
105	21.39±0.20	0.10±0.03	0.91±0.77	97.37±0.41
SD	0.3136	0.0230	0.0795	0.5757
Conf/inter with $p < 0.05$	0.3894	0.0286	0.0987	0.7148
**Note*: Each value is expressed as the mean ± SD ($n = 3$). Means with different letters within a column are significantly different ($p < 0.05$).				

The desulfurized WPA, characterized by a composition of 20.53 % P_2O_5, 0.28 % CaO, 0.27 % MgO, 0.45 % Fe_2O_3, 0.62 % Al_2O_3 and 0.10 % SO_3, underwent controlled evaporation to achieve a predetermined P_2O_5 content. This evaporation process was conducted under atmospheric pressure within a tubular quartz reactor, featuring a bladed quartz stirrer and heated externally by a specialized electric furnace. The resulting evaporated phosphoric acids exhibited concentrations ranging from 45.62 % to 60.34 % P_2O_5. Notably, visual observation indicated that as the concentration of P_2O_5 increased during the evaporation of WPA, the fluid state of the solution was maintained without thickening. However, an increase in P_2O_5 concentration corresponded to a noticeable increase in sediment volume. This phenomenon suggests that, as the initial WPA undergoes concentration, phosphates of cationic impurities, including strontium, calcium, sodium, and potassium sulfate, crystallize due to a reduction in their solubility. The composition of the resulting evaporated phosphoric acids is depicted in Figure 1, providing a visual representation of the evolving chemical composition during the controlled evaporation process.

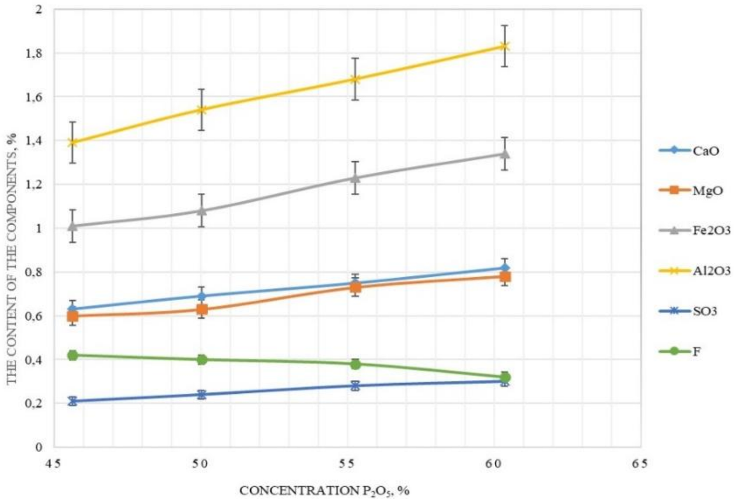

Figure 1. The content of impurity components in the evaporated acid depends on the concentration of phosphorus pentoxide

In order to regulate the evaporation process of WPA and, consequently, produce concentrated fertilizers and feed phosphates with acceptable transport and storage conditions, a thorough examination of the physical and chemical properties was conducted. This included a study of the boiling point at varying concentrations of WPA (ranging from 45.62 % to 60.34 %) without the clarification stage. The investigation considered the P_2O_5 content and residual pressure values in the system, which ranged from 743 to 443 mm Hg. Additionally, the elasticity of vapors above these acids was explored, contingent on the concentration of WPA (45.62–60.34 % P_2O_5) and temperatures ranging from 293 to 333 K. The constants A and B were determined by applying of the Claesus-Clapeyron equation, utilizing the least squares method. Subsequently, empirical equations were derived to predict the pressure of saturated vapors over solutions at different temperatures. The relationship between saturated vapor pressure and temperature follows a specific equation, as depicted in Figure 2. These findings contribute crucial insights into the thermodynamic characteristics of WPA solutions during the evaporation process, facilitating the optimization of conditions for the production of concentrated fertilizers and feed phosphates with desirable transport and storage attributes.

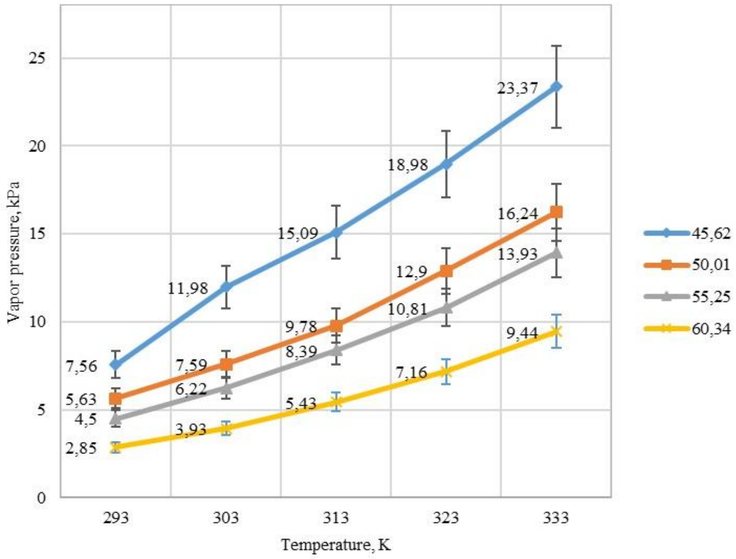

Figure 2. Elasticity of saturated vapors over desulfurized evaporated phosphoric acid

Figure 2 illustrates the concentration-dependent characteristics of WPA with P_2O_5 concentrations ranging from 45.62 % to 60.34 %. The constants *A* and *B*, within this range, span 5.1838–979.5 and 5.6399–1263.5, respectively. Across the temperature range of 293–333 K, an inverse relationship is observed between vapor pressure and WPA concentration. Higher temperatures correspond to increased saturated vapor pressure above the acid. Specifically, at 293–313 K, the measured pressure of saturated vapors over evaporated WPA samples ranges from 2.85–23.37 kPa, indicating low volatility in the arid climate of Central Asia. This low volatility suggests prolonged storage stability without significant changes in physico-chemical properties.

The boiling points of the evaporated WPA samples are depicted in Figure 3.

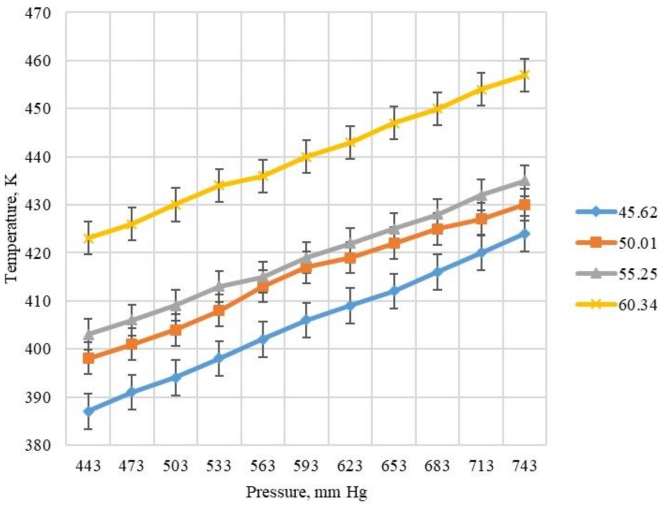

Figure 3. Boiling point of desulfurized evaporated phosphoric acid

The data in Figure 3 establish a direct relationship between the concentration of WPA and the boiling point of its solutions. An increase in the concentration of WPA corresponds to a higher boiling point. For instance, at a concentration of 45.62 % P_2O_5 and a pressure of 743 mm Hg, the boiling point is recorded at 424 K or 131 °C. Similarly, at a concentration of 50.01 %, the boiling point elevates to 137 °C, further rising to 165 °C for a concentration of 55.25 % P_2O_5 and reaching 184 °C at a concentration of 60.34 % P_2O_5. Notably, a reduction in pressure significantly decreases the boiling point of WPA solutions.

As P_2O_5 concentration in WPA exceeds 45.62 %, visible precipitation of insoluble particles and salts becomes evident, intensifying with higher P_2O_5 concentrations, particularly reaching prominence at 60.34 %. This escalating P_2O_5 concentration leads to reduced solubility of elements such as Fe, Al, Ca, Mg, resulting in heightened crystallization. Analytical methods were employed to quantify P_2O_5 and associated impurities. The observed precipitate, rich in iron and aluminum phosphates, serves as a phosphorus component in phosphorus fertilizers. Those with P_2O_5 content between 17.94 % and 21.42 % are returned to ammonium phosphate production for amalgamation with ammonium phosphate pulp (Table 3).

Table 3

The composition of precipitation formed during the evaporation of desulfurized WPA washed with acetone

	Concentration P_2O_5, %	The content of the components, % (± Confidence interval with Student's distribution in $\alpha = 0.05$)				
		CaO	MgO	Fe_2O_3	Al_2O_3	SO_3
	21.42±0.50	9.25±0.60	2.77±0.4	4.68±0.15	2.35±0.30	5.74±0.50
	28.54±0.52	6.49±0.70	1.39±0.35	6.51±0.90	3.17±0.25	4.88±0.40
	17.25±0.40	7.43±0.65	0.39±0.30	7.51±0.80	3.03±0.15	5.02±.030
	17.94±0.43	18.38±0.55	0.39±0.20	1.39±0.70	4.21±0.20	18.3±0.90
SD	5.7089	1.4032	1.1950	1.4351	0.4386	0.4614
Conf/inter with p<0,05	9.0841	2.2328	1.9016	2.2836	0.6980	0.7343

In this investigation, the precipitated $SrSO_4$ resulting from the desulfurization process of the initial WPA, along with precipitates obtained during the evaporation of the clarified portion of desulfurized WPA to distinct concentrations (45.62 %, 50.01 %, 55.25 % and 60.34 % P_2O_5), underwent a thorough washing with acetone to attain a neutral state. Following the drying of these samples, infrared (IR) spectroscopic analyses were conducted. The analyses were carried out using a Perkin-Elmer FT-IR Spectrum 3 spectrophotometer [18], operating within a frequency range of 4000–400 cm^{-1}. The accuracy of the results obtained was ensured through verification against specific references [19, 20]. Figures 4–8 depict the outcomes of the IR spectroscopic analysis. Two important concepts are discussed here: transmittance (% *T*) and wavenumber ($cm^{–1}$).

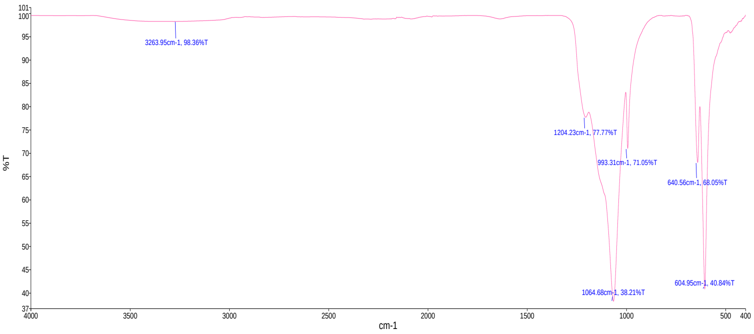

Figure 4. IR spectroscopic analysis of the precipitate of desulfurized evaporated $WPA_{(initial)}$

Figure 4 reveals the results of the IR spectroscopic analysis of the precipitate obtained through the desulfurization process with $SrCO_3$ of the initial extracted phosphoric acid. Wavelengths of 604.95 and 640.56 $cm^{–1}$ are identified, corresponding to the $SO_4^{2–}$ ion, while the wavelength of 993.31 $cm^{–1}$ corresponds to the $PO_4^{3–}$ ion. Additional features are noted at 1064.68 $cm^{–1}$ for the (S=O) bond, 1204.23 $cm^{–1}$ for (C–O), and 3263.95 $cm^{–1}$ for (O–H), as suggested by certain sources.

Figure 5 shows the IR spectroscopic analysis of the precipitate obtained after the evaporation of desulfurized WPA with $SrCO_3$ to a concentration of 45.62 % P_2O_5 is presented. Wavelengths of 474.86, 492.00, 580.02, 919.30, 967.80 and 1061.53 $cm^{–1}$ are indicative of the $PO_4^{2–}$ ion, while the wavelength of 712.23 $cm^{–1}$ suggests the presence of the (POH) bond. Moreover, sources propose the existence of the (C=C) bond at a wavelength of 1631.08 $cm^{–1}$ and the (O–H) bond at 3039.38 $cm^{–1}$. Confidence interval was maintained at 95 %.

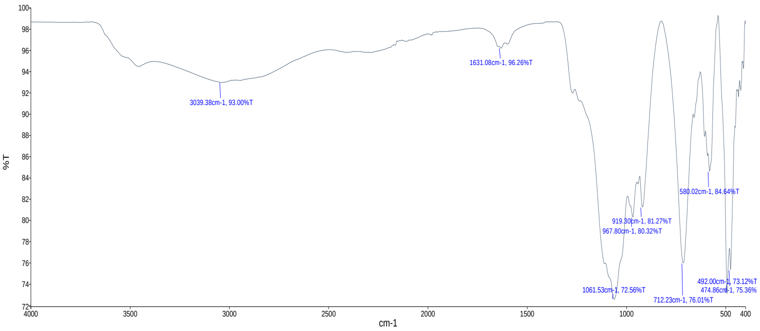

Figure 5. IR spectroscopic analysis of the precipitate of desulfurized evaporated WPA with a content of 45.62 % P_2O_5

In Figure 6, the IR spectroscopic analysis of the precipitate obtained after the evaporation of desulfurized WPA with $SrCO_3$ to 50.01 % P_2O_5 reveals wavelengths of 493.23, 578.67, 920.61, 966.96 and 1051.04 $cm^{–1}$ corresponding to the $PO_4^{2–}$ ion. Additionally, the wavelength of 720.15 $cm^{–1}$ indicates the presence of the (POH) bond. Some sources suggest the existence of the (C–O) bond at 1273.57 $cm^{–1}$, the (C=O) bond at 1634.84 $cm^{–1}$, and the (O–H) bond at 3039.86 $cm^{–1}$.

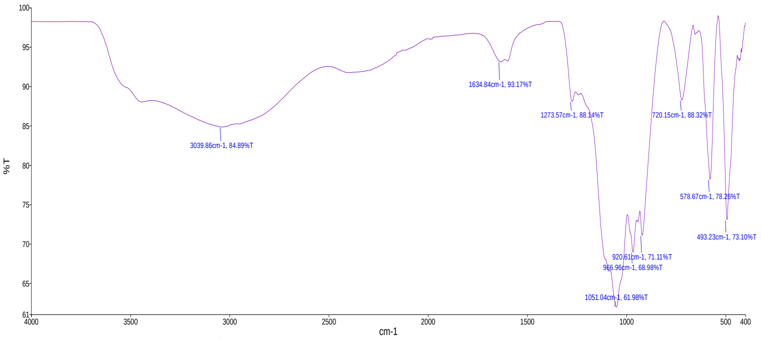

Figure 6. IR spectroscopic analysis of the precipitate of desulfurized evaporated WPA containing 50.01 % P_2O_5

Moving to Figure 7, the IR spectroscopic analysis of the precipitate obtained after the evaporation of desulfurized WPA with $SrCO_3$ to 55.25 % P_2O_5 indicates wavelengths of 430.93, 493.74, 579.48, 919.83, 967.37 and 1053.36 cm^{-1} corresponding to the PO_4^{2-} ion, with a wavelength of 715.05 cm^{-1} indicating the presence of the (POH) bond. Sources also indicate the presence of the (C=O) bond at 1598.97 cm^{-1} and the (O–H) bond at 2977.29 cm^{-1}.

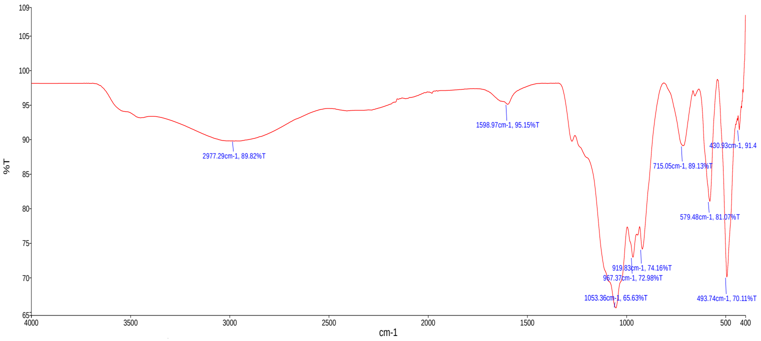

Figure 7. IR spectroscopic analysis of the precipitate of desulfurized evaporated WPA containing 55.25 % P_2O_5

Figure 8 illustrates the IR spectroscopic analysis of the precipitate obtained after the evaporation of WPA desulfurized with $SrCO_3$ to 60.34 % P_2O_5. Wavelengths of 494.85, 606.22, 651.84, 992.78, 1066.08 and 1111.16 cm^{-1} correspond to the PO_4^{2-} ion, while the wavelength of 724.55 cm^{-1} indicates the presence of the (POH) bond. Additionally, sources [18, 19] suggest the existence of the (C=O) bond at 1635.67 cm^{-1} and the (O–H) bond at 3117.42 cm^{-1}.

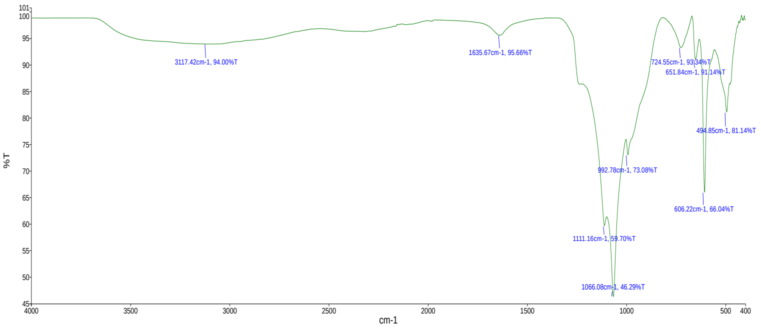

Figure 8. IR spectroscopic analysis of the precipitate of desulfurized evaporated WPA containing 60.34 % P_2O_5

Conclusion

In conclusion, this investigation elucidates the proficient desulfurization of weak WPA sourced from Washed Burnt Phosphoconcentrate-26 (WBP–26) via strategic application of strontium carbonate, culminating in the attainment of a substantial concentration, specifically 60 % P_2O_5, through a meticulously executed process of evaporation. The empirical analysis substantiates the salient attribute of low volatility exhibited by the resultant concentrated WPA, a characteristic particularly germane in regions characterized by heightened thermal conditions, as underscored by the delineated range of saturated vapor pressures.

Furthermore, the concentrated phosphoric acid exhibits notable versatility, affirming its aptitude for the synthesis of premium-grade fertilizers, including Monoammonium Phosphate (MAP) and Diammonium Phosphate (DAP), alongside its applicability in the production of feed phosphates. Significantly, this research augments scholarly discourse by shedding light on the compound's nuanced involvement in the formulation of liquid complex fertilizers, featuring ammonium polyphosphates characterized by specific $N:P_2O_5$ ratios. As a scholarly endeavor, this inquiry advances our comprehension of phosphorus-rich fertilizer production paradigms, contributing to the refinement of agro-industrial methodologies with tangible implications for optimized agricultural practices.

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Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript. CRediT: **Ilkhom Erkin ugli Khoshimov** conducts a thorough purification of extraction phosphoric acid of phosphorites of the Central Kyzylkum; **Shakhzoda Ismatullaevna Turdialieva** took part in research and analysis of scientific and technical literature; **Atanazar Reypnazarovich Seytnazarov** substantiated the idea of conducting research on the development of technology for purifying WPA and its practical application, and also took part in writing the article; **Shaffat Sattarovich Namazov** created the conditions for conducting all laboratory experiments, the formulation of the goals and objectives of the research; **Mohamed Rifky** contributed to the calculations involving standard deviations, confidence intervals, approximation errors, and coefficients of determination, as well as addressing the reviewer's comments.

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Conflicts of Interest

The authors declare no conflict of interest.

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