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Research Article

Measurement Of Solid Matter Methods

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Abstract: The classification of moisture measurement methods cannot be organized without linking them to liquid or gas moisture measurement methods. Extraction of water from a solid in solution is widely used in physical chemistry. At the end of the extraction, the amount of water in the liquid is measured. Using the principle of evaporation of water in a solid, it is transferred to the gas and the moisture content in the gas is determined. Methods of measuring moisture in solids are divided into methods such as nuclear-physical, optical, physical, electrophysical, physicochemical and extraction-chemical.

Keywords: extraction, moisture, solution, substance, atmosphere, partial pressure, mercury column, degree, direct, indirect, quantity measured, optical methods, sorption-gravimetric.

1. Literature review

Determining the relative humidity of the air or the humidity of the substances was considered a very important task. Too humid and too dry air is harmful to nature, objects, food and the human body. Therefore, it is important to know in advance the humidity and climatic conditions of the substances. To this end, the concepts of absolute and relative humidity have been introduced in the description of air humidity. Humidity is said to be a quantity that characterizes the presence of water vapor in the Earth's atmosphere. The amount of water vapor in the atmosphere varies depending on various factors, namely the geographical location of the area, the season and the time of day.

Absolute humidity is equal to the mass of water vapor (in grams) in 1 m of air. It is difficult to measure the amount of steam in the air directly. However, the quantitative value of absolute humidity differs little from the value of partial pressure. The pressure created by only water vapor in the air is called the partial pressure of water vapor. Partial pressure is one of the quantities that indicates the humidity of the air, which is measured in pascals or mercury.

It is difficult to know how dry or humid the air is by determining the absolute humidity of the air. Because the dryness or humidity of the air also depends on the temperature of the air. When the given temperature is low, a certain amount of water vapor may be close to saturation, while at high temperatures that amount of water vapor may be far from saturated. In the first case the air is humid, in the second case it is dry [1].

To think about the humidity level of the air, it is necessary to know how far or close to saturation the water vapor in it is. Therefore, the concept of relative humidity is introduced.

Relative humidity, absolute humidity ρ_a at a given temperature, the density of water vapor that saturates the air $\rho_{\text{т}}$ is determined by the percentage of, and is written mathematically as follows :

$$\varphi = \frac{\rho_a}{\rho_{\text{т}}} \cdot 100\%$$

Relative humidity is a quantity measured by the ratio of the partial pressure of water vapor in the air to the partial pressure of water-saturating water vapor at a given temperature. This magnitude can be expressed as follows:

$$\varphi = \frac{\mathrm{P}_a}{\mathrm{P}_{\mathrm{T}}} \cdot 100\%$$

The density of steam that has the ability to saturate the air with decreasing temperature $\rho_{\text{т}}$ decreases, this concept leads to an increase in relative humidity. Relative humidity without changing the amount of water vapor in the air with decreasing temperature 100 % can be transmitted to. Relative humidity 100 % is called the dew

point. If the temperature is slightly below the dew point, then the vapor will begin to condense and dew drops will form in the mist or various bodies [2-3].

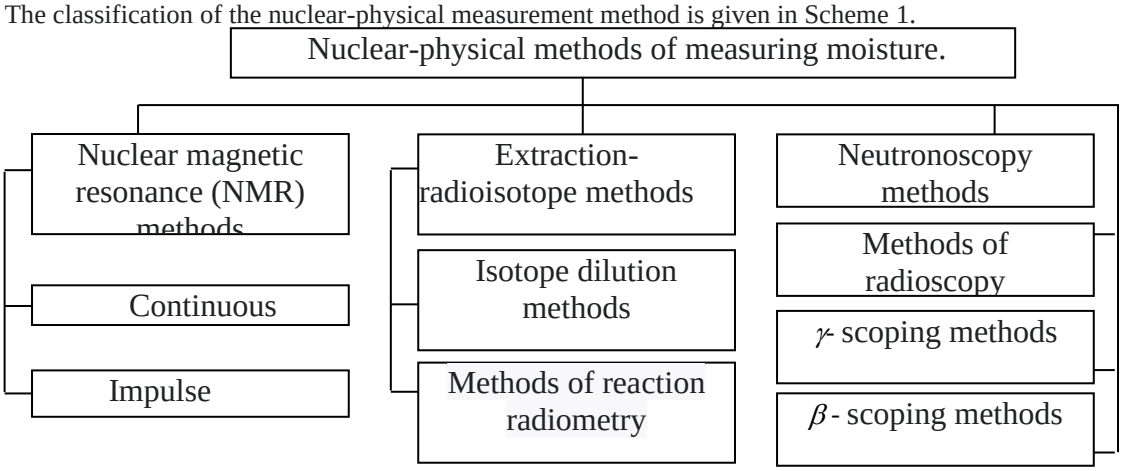
2. Methodology

Moisture measurement methods are divided into direct and indirect measurements. The direct method is applied based on the physical and chemical nature of the substances. The indirect method is used in cases where the properties of the substance depend on moisture.

The classification of moisture measurement methods cannot be organized without linking them to liquid or gas moisture measurement methods. For example, the extraction of water from a solid in solution is widely used in physical chemistry. At the end of the extraction, the amount of water in the liquid is measured. The water in the solid is transferred to the gas using the principle of evaporation, and the amount of moisture in the gas is determined.

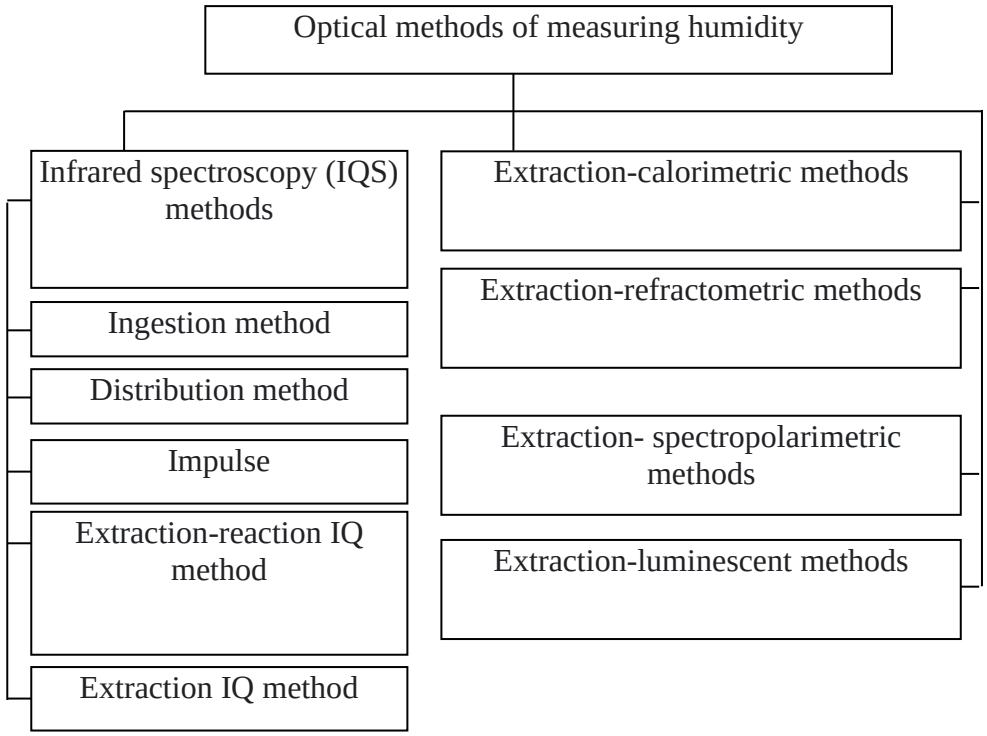
Methods for measuring moisture in solids are divided into methods such as nuclear-physical, optical, physical, electrophysical, physicochemical and extraction-chemical.

The classification of the nuclear-physical measurement method is given in Scheme 1.



Scheme 1. Nuclear-physical methods of measuring moisture.

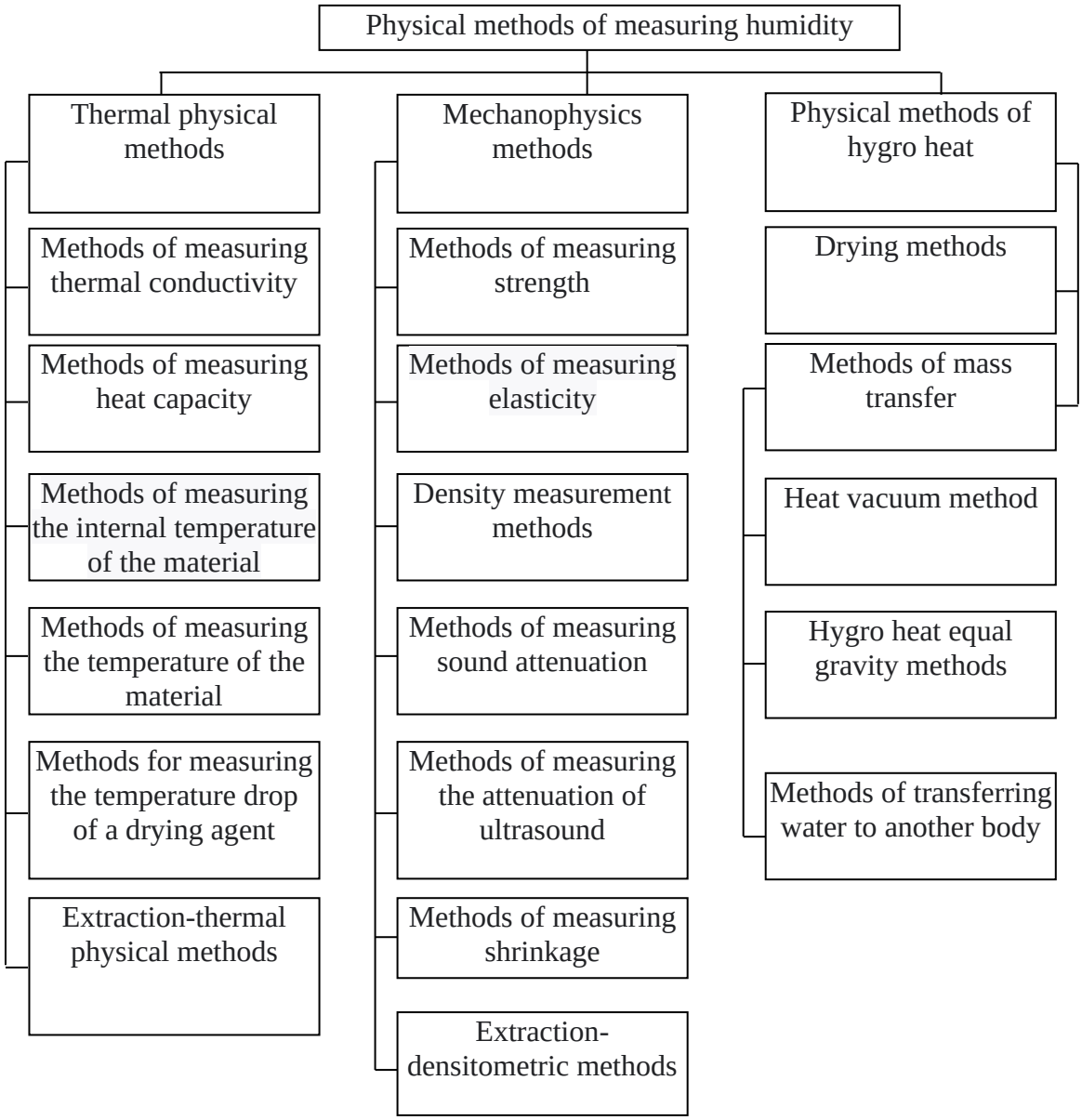
Optical methods of moisture measurement are described in Figure 2, which uses the infrared (IR) spectroscopy method based on the dependence of the absorption intensity of a substance on moisture or the effect of infrared rays.



Scheme 2. Optical methods of measuring humidity.

Physical methods for measuring the moisture content of solids are shown in Figure 3 described. These thermal physical methods are based on the moisture dependence of the heat capacity and thermal conductivity of a substance, taking into account the temperature difference between the temperature of the material during its drying process and its passage through the drying material. Extraction-heat physical measurements are the separation of the amount of water in a solid from several solutions, and then the concentration in the solution and the necessary calculations are determined using any thermal physical method. In this method, the most common hygro-thermal methods of drying the sample of the substance, which belong to the physical methods, are divided into various modifications and methods of mass transfer. the thermal vacuum method includes methods based on the hygro heat equal attraction of a wet gas (air) in a wet material [4].

The main methods of drying are evaporation (evaporation), sublimation (freezing), sorbent drying.



Scheme 3. Physical methods of measuring humidity.

Evaporation drying consists of a nomenclature of parameters specified in the heat transfer to the material, the method of sample preparation, technology (sequence of operations) due to the mutual differentiation of these conditions.

Drying conditions are characterized by the drying of the agent or the temperature of the element being dried, atmospheric pressure, ambient humidity, drying time, circulation of the description of the construction unit, the

heat transfer unit of the unit and its characteristics. The drying unit or element to be dried is regulated by three parameters, which are: the value of the average temperature of the drying elements or the volume of the evaporating chamber (depending on the task of analysis and the type of material), the amplitude change of temperature, the homogeneity of the temperature field.

The pressure in the evaporator chamber may be equal to or less than atmospheric pressure. In the latter case (vacuum drying) the minimum impact loss rate or its average value and the vibration amplitude (automatic pressure adjustment mode or vacuum presence) are set. The humidity of the environment depends on the non-regulation (non-regulation) of the measurement result, the stability, in this case the amplitude of vibration and the requirements set for its average value.

The drying time of the material sample is measured in three ways. In the simplest case, the drying time (e.g. 40 minutes) is indicated (depending on the type of material). In many cases, the drying time is not regulated, i.e. the time interval from the drying time to the determination of the mass of the substance varies. In some cases, the duration of the drying process depends on the rate of change of the mass (drying is completed after the specified rate is constant) [4].

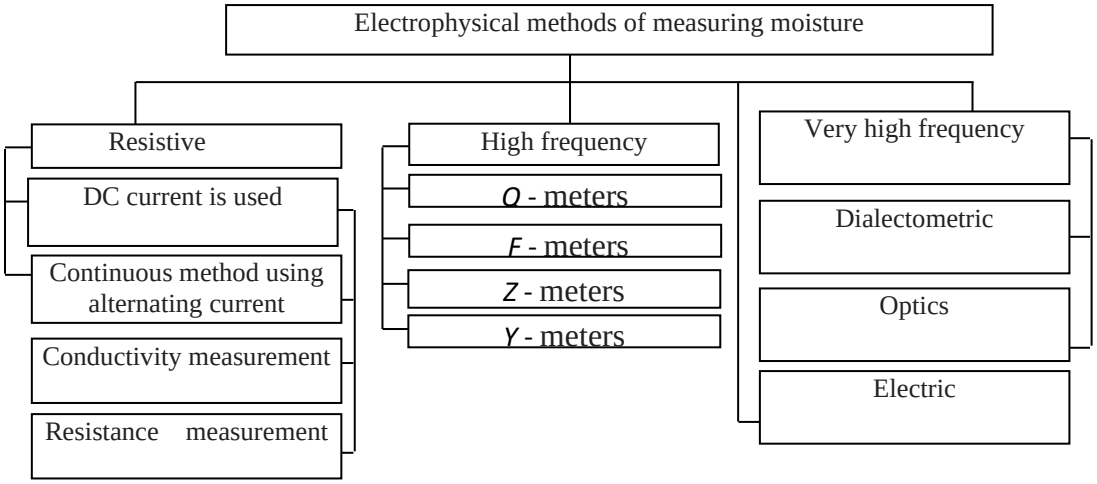
The mass is determined independently or by recording the specified automatic results or without their help. Condensation-gravimetric, sorption-gravimetric, chemical-analytical, coulometric, gasometric and other methods used in hygrometry are used to determine the mass (amount) of evaporated water.

The drying method differs from the method of preparation of cross-samples. The moisture content of a sample of a substance is reduced to a fragment before measurement. There are a number of tasks to identify and control: the vessel; sample preparation conditions; accuracy of calculation of drying duration and sample preparation time; the condition of the sample is granular and sanitary; determined by the presence in the mixture and other requirements.The sample may be crushed or not crushed before drying.For the moisture state of the sample, the requirements for pre-grinding and grinding quality control are determined by the size of the crushed product parts, the technical characteristics of the grinding device or others in relation to the final state [4-6].

It is possible to develop and master the comparative work using the thermal vacuum (thermovacuum) method, which belongs to the hygro-thermophysical method of measuring the moisture content of solids. Its advantage is that it takes into account that the rate of evaporation of water in the finely dispersed substance is functionally dependent on the moisture content of the substance. As the water in the sample of the substance evaporates, its temperature decreases as a non-uniform state occurs.In thermovacuum moisture meters, a vacuum is formed over a short period of time at the top of the analyte, during which the sample temperature is recorded. As the intensity of the water vapor in the sample increases, its temperature decreases to a minimum value for a while and then rises again. The temperature difference in the initial state of the substance and the maximum intensity of the water vapor are theoretically and experimentally functionally dependent on the moisture content of the material.

Moisture measurements are based on the formation of sorbents in the mass transfer method, which is characterized by the delivery of water from the analyte to another very stable equilibrium property. This method is used in more soil moisture measurements. Used for gypsum block, ion exchange glue and other substances. During the detection time, a hygrometric equal gravity is generated between the analyte and the starting material. In the latter case, the humidity is measured using an electrophysical method [7].

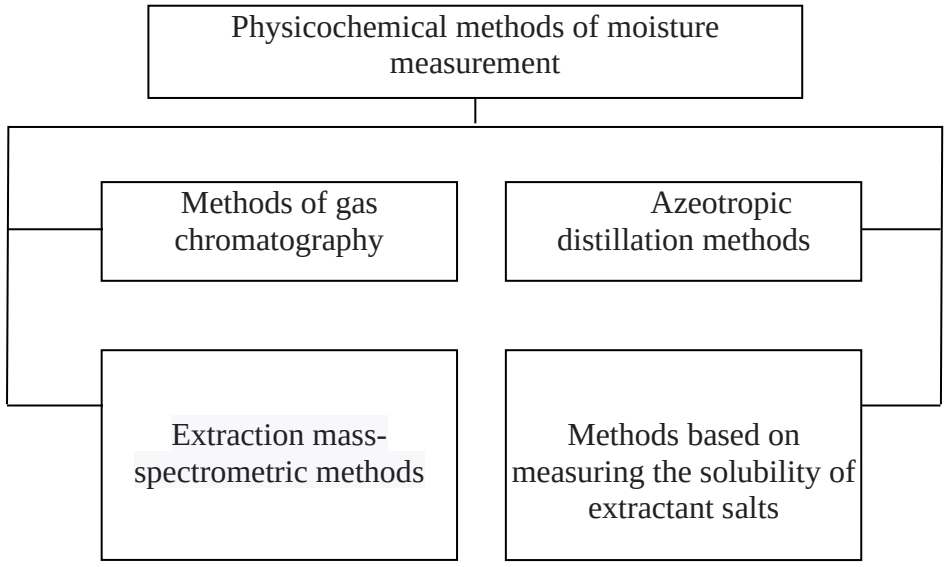
A sufficiently widely used method in moisture measurements is a method based on the reciprocal hygrothermal equal attraction between the material under analysis and the closed environment (e.g., air). In this case, the equilibrium of the wet states of the gas between the parts of the material in space is established, and the moisture content of the scattering substance is determined by the moisture characteristics.



Scheme 4. Electrophysical methods of measuring moisture.

The most common electrophysical methods for measuring the moisture content of solids are shown in Figure 4. This method involves the constant presence of moisture in a substance and its conductivity (electrical resistance), dielectric constant or dielectric loss (high-frequency method of electric current at a frequency of several tens of megahertz), ultra-high-frequency field energy extinction (wavelength 10 mm and above). based on the relationship between electric charges in an electric field.

Express and technological moisture meters are mainly used in the industry. Among them, purpose-built devices are made on the basis of extraction electrophysical methods. In this case, the water in the solid is separated from the mixture, and then its amount is determined electrophysically. Physicochemical methods of moisture measurement are described in Figure 5. This gas is used in chromatography (color photography), azeotropic distillation, mass spectroscopy, and depending on the salinity of the mixture and the moisture content of the mixture.



Scheme 5. Physicochemical methods of moisture measurement.

The amount of water in the azeotropic distillation is determined by measuring the volume or mass of the sample under analysis in an organic mixture medium in a special trap-receiver after firing.

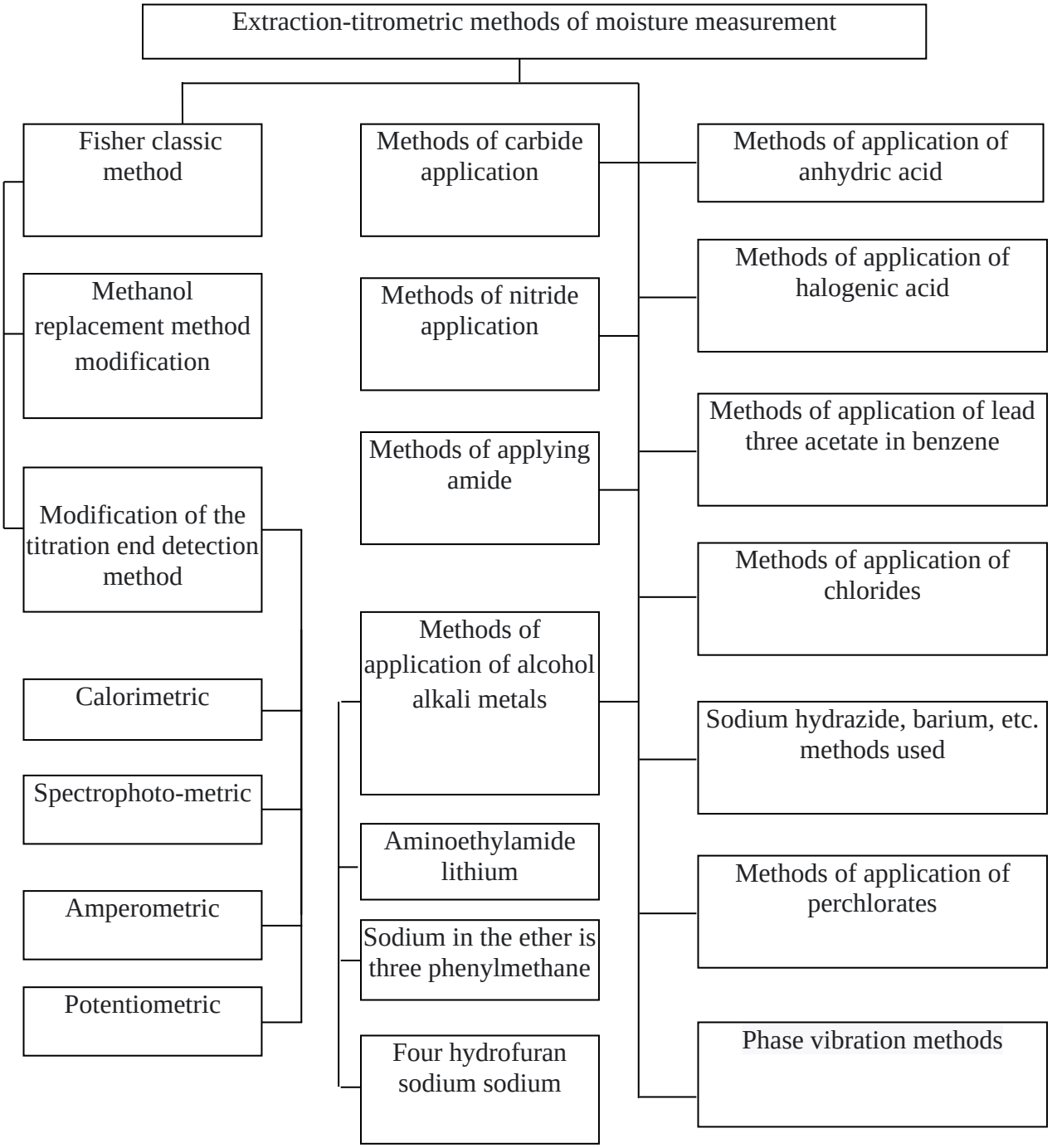
Methods based on the moisture dependence of a solution of different salts in a liquid are relatively numerous. This method is often applied to all silver perchlorates. Benzene, toluene, ether are used as a medium for water separation.

The most modern of the extraction-chemical methods are dielectric and extraction-gasometric. The essence of the extraction-gasometric method is as follows: if a large amount of hydrogen is released from the aqueous inert

solution of calcium hydride (or any other hydride) in the mixture. At a temperature not exceeding 150 °C, the reaction effect is expressed as follows.

$$CaH_2+2H_20=Ca(OH)_2+2H_2;$$

It follows from the calculation of the reaction that, 1 sm^3 for hydrated water 1240 sm^3 hydrogen is released. A working device on this principle can be a "chemical amplifier" with a volume of water with a gain of 1240. The method can have several different appearances.

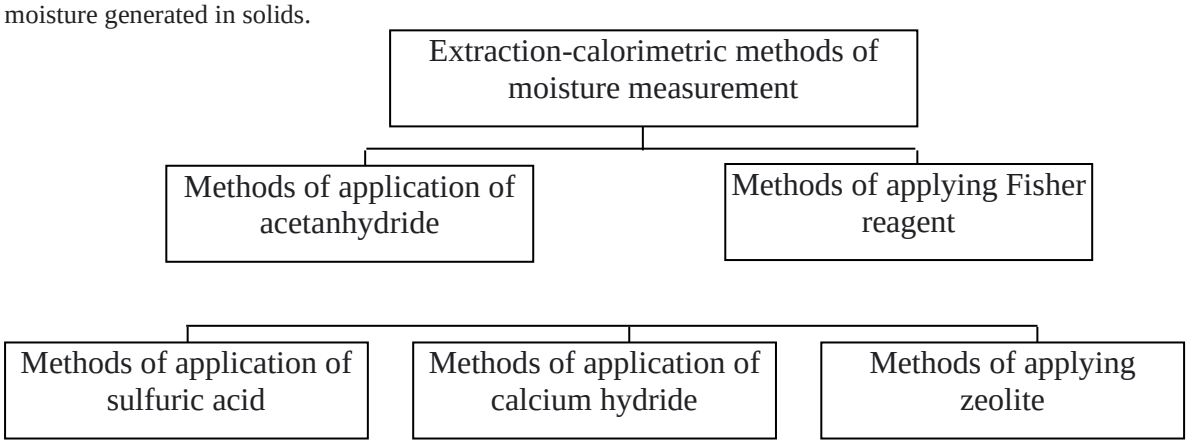


Scheme **6.** Extraction-titrometric methods of moisture measurement**.**

The chemical-extraction method includes a large number of titrimetric methods, which are described in Figure 6. The essence of these methods is as follows: as a result of the reaction of some chemicals with water, new compounds (alkalis, acids, etc.) are formed, the amount of which is determined by titration using a suitable titrant. From the amount of titrant used in the titration, a conclusion is drawn about the amount of water in the extractant. The Fisher method, which belongs to this method, is the most common.

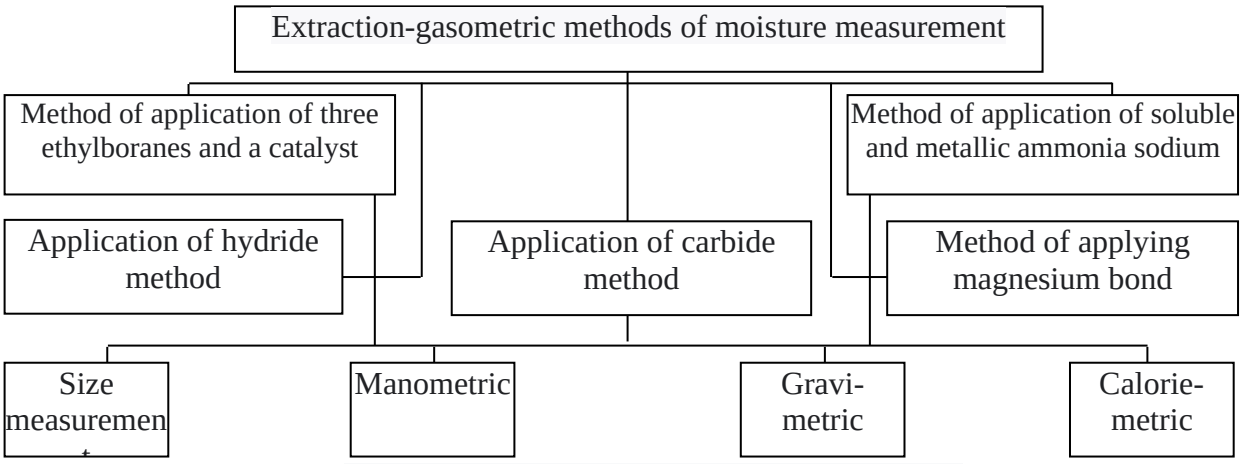
The extraction-calorimetric method of measuring moisture includes methods using a large number of acetanhydrides and methods using sulfuric acid. The appearance of this method is illustrated in Figure 7. The essence of these methods is that as a result of the reaction of some chemicals with other substances, new compounds (alkalis, acids, etc.) are formed, the amount of which is determined by titration, which is formed by the appropriate reaction.

The extraction-calorimetric method of measuring moisture is also the most effective method for determining the moisture generated in solids.



Scheme 7. Extraction-calorimetric methods of moisture measurement.

In a sufficiently large number of measurements of the group of extraction-gasometric methods are described in Scheme 8.



Scheme 8. Extraction-gasometric methods of moisture measurement.

In this method, gas (hydrogen, methane, acetylene, etc.) is released under the chemical action of some reagents of water. The amount of gas released is measured and the measurement result is used to calculate the water concentration in the extractant.

The coulometric moisture measurement method is generated directly in the coulometric cell by the titrant electrochemical method that reacts with this water. The amount of water in the extractant is inferred from the amount of electricity used to form the titrant.

The potentiometric method is based on the dependence of the concentration of water in the extractant on the glass electrode potential. Used at small values of water concentration.

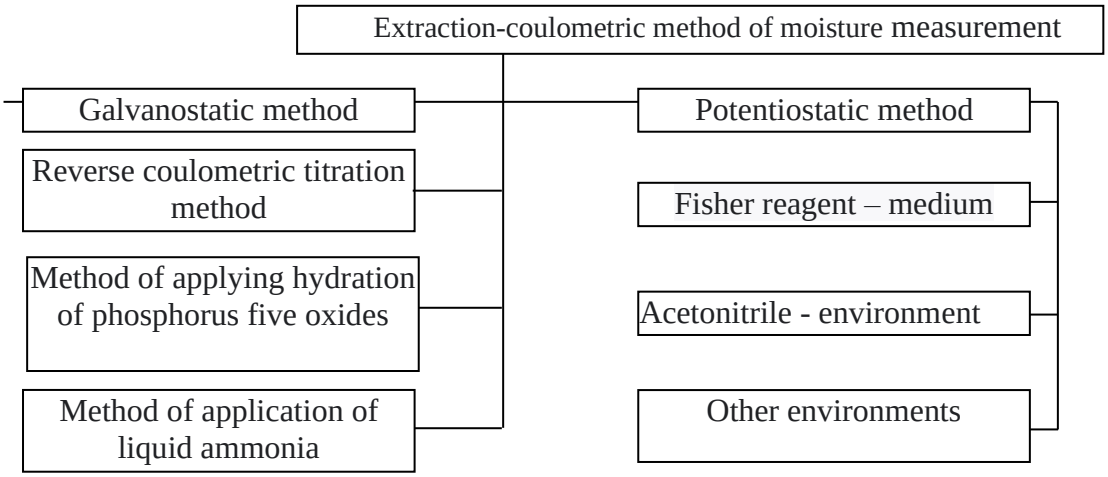
The polyarographic method will be based on the electrochemical oxidation of the diffusion boundary current or the return of the substance concentration to its place. Typically, this method is used to determine the small amount of water in organic extracts.

The conductometric method of measuring humidity is based on the dependence of the electrical conductivity of extractants on the concentration of water present in the system. This method is more commonly used in measuring aproton extractant moisture.

The dielecometric method is currently one of the most convenient methods of measuring humidity. The method is based on the fact that changes in the moisture content of capillary-porous bodies greatly alter their dielectric constant.

The method of liquid chromatography is based on the measurement of the moisture content of the extractant in the absorption columns.

The extraction-coulometric method of measuring the moisture content of solids is described in Scheme 9 and is mainly performed in four different ways. Galvanostatic, potentiometric, reverse coulometric titration and methods of reacting it with water using various reagents. As a result of the reactions, an electric current is released.



Scheme 9. Extraction-coulometric method of moisture measurement.

The galvanostatic method of measuring moisture is based on the fact that the amount of water in the extractant depends on the amount of electricity. The process of reacting with water takes place at the expense of the consumed electric current in the consumable electrochemical titrant cell. This vibration is performed at constant current [8].

The potentiometric method of measuring moisture is based on the dependence of the amount of water in the extractant on the amount of electricity, in which the spent chemicals (iodine, acenitrile, etc.) entering the excess coulometric cell are returned to their place. The reduction is performed at a constant potential cathode.

Reverse coulometric titration is the titration of a special excess amount of Fisher reagent in the extractant and the aqueous solution of excess iodine in the extractant (e.g., methanol).

The essence of the coulometric method is to form a chemical bond with water using different reagents, the electrochemical decomposition of which depends on the amount of water in the extractant and the moisture content of the test substance.

One of the modern methods of measuring moisture - an analysis of the current state of grain moisture meters:

Draminsky moisture meter. A modern moisture meter for grain and grain products of capacitive type on farms. Ranked for 15 different materials of different sizes. It is battery-powered and requires little power. Easy to operate. Measurement error 1%. The error compared to the measurement method is minimized. The interior of this device uses a coaxial capacitor, the design of which is very simple.

3. Conclusion

This paper presents a number of methods for measuring the moisture content of solids, and the physical methods in the measurements are clearly described. Physical measurement methods are divided into thermal-physical, mechnophysical and hygro-thermal physical groups.

The physically relevant methods of heating are based on the dependence of the heat capacity and thermal conductivity of a substance on moisture, taking into account the temperature difference between the temperature of the material during its drying process and its drying through the material being dried. This group belongs to the extraction-heat physical group, in which the amount of water in a solid is separated from several solutions, and then it is explained that the concentration in the solution and the necessary calculations can be determined using any thermal physical method.

It is explained that the methods of drying a sample of a substance, which belong to the most common hygro-thermal physical methods, include various modifications and mass transfer methods, ie heat-vacuum method, based on the hygroscopic methods of wet gas (air) in wet material.

It is not necessary to comment on the method of drying the material sample, as it is one of the most common methods. The main methods of drying are evaporation (evaporation), sublimation (freezing) and drying. The article notes that methods for determining the moisture content of solids are topical tasks.

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