

ATHEORITICAL STUDY ON STRUCTURAL PROPERTIES OF POLYVINYL ALCOHOL

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ABSTRACT

This investigation shows the different structural, physical and chemical properties of polyvinyl alcohol. The nature of polyvinyl alcohol alongside its functional properties is discussed also. It features recent advances in pure PVA and its composites containing different Nano fillers that have potential applications in different fields. Over 50 years, PVA is known as a propitious material for diverse applications. The review focuses on the structural, mechanical, optical, and electrical properties of PVA based Nano composites.

KEYWORD: *Polyvinyl, Alcohol, Structure, properties, Etc.*

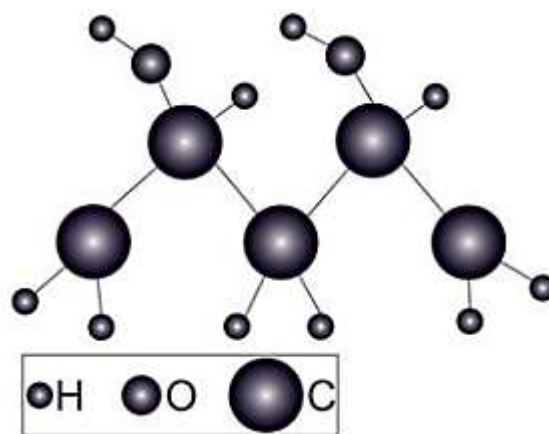
1. INTRODUCTION

1.1 Polyvinyl alcohol

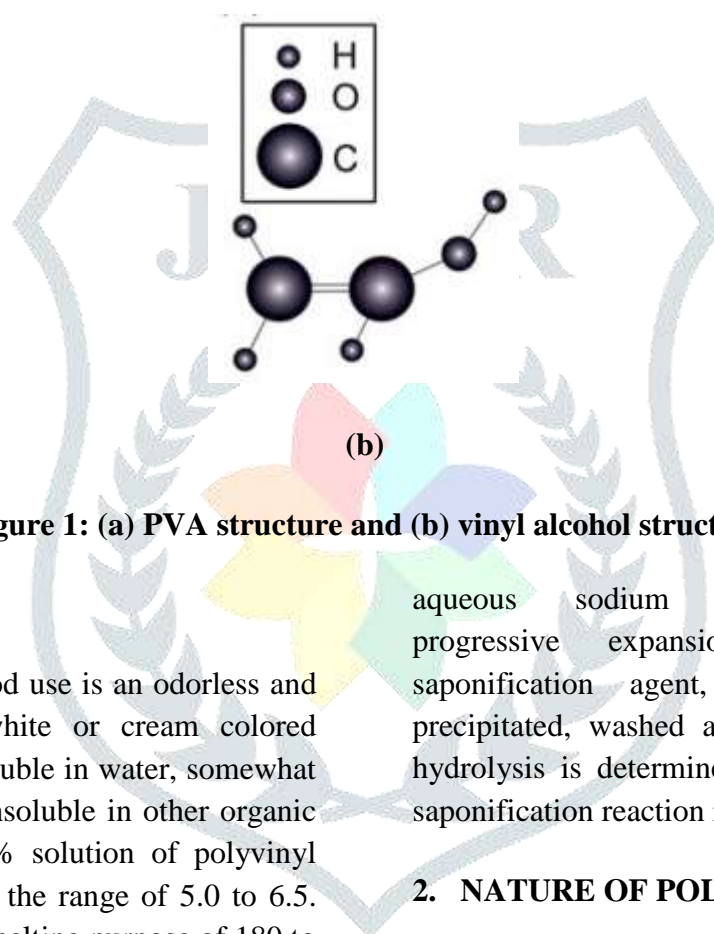
Polyvinyl alcohol was placed on the agenda of the 61st JECFA. Polyvinyl alcohol was first prepared by Hermann and Haehnel in 1924 by hydrolyzing polyvinyl acetate in ethanol with potassium hydroxide. Polyvinyl alcohol is produced commercially from polyvinyl acetate, generally by a nonstop process. The acetate bunches are hydrolyzed by ester interchange with methanol in the presence of anhydrous sodium methylate or aqueous sodium hydroxide. The physical characteristics and its specific functional uses depend on the degree of

polymerization and the degree of hydrolysis. Polyvinyl alcohol is classified into two classes namely: mostly hydrolyzed and completely hydrolyzed. Incompletely hydrolyzed PVA is used in the nourishments.

Polyvinyl alcohol is an odorless and tasteless, translucent, white or cream colored granular powder. It is used as a moisture barrier film for food supplement tablets and for nourishments that contain incorporations or dry food with considerations that need to be protected from moisture uptake. Polyvinyl alcohol isn't referred to happen as a characteristic item.



(a)



(b)

Figure 1: (a) PVA structure and (b) vinyl alcohol structure

1.2 Description

Polyvinyl alcohol for food use is an odorless and tasteless, translucent, white or cream colored granular powder. It is soluble in water, somewhat soluble in ethanol, yet insoluble in other organic solvents. Normally a 5% solution of polyvinyl alcohol exhibits a pH in the range of 5.0 to 6.5. Polyvinyl alcohol has a melting purpose of 180 to 190°C. It has a molecular weight of between 26,300 and 30,000, and a degree of hydrolysis of 86.5 to 89%.

1.3 Manufacturing

The essential crude material used in the manufacture of polyvinyl alcohol is vinyl acetate monomer. It is manufactured by the polymerization of vinyl acetate followed by partial hydrolysis. The process of hydrolysis is based on the fractional replacement of ester bunch in vinyl acetate with the hydroxyl gathering, and is completed in the presence of

aqueous sodium hydroxide. Following progressive expansion of the aqueous saponification agent, polyvinyl alcohol is precipitated, washed and dried. The degree of hydrolysis is determined when point where the saponification reaction is stopped.

2. NATURE OF POLY (VINYL ALCOHOL)

PVA is a creamy or whitish, tasteless, odorless, nontoxic, biocompatible, thermostable, granular or powdered semi crystalline or linear synthetic polymer. It possesses astounding optical properties, large dielectric strength, and excellent charge storage capacity. Its mechanical, optical and electrical attributes can readily be tailored by doping with nanofillers. PVA is available on the market in different grades based on consistency and degree of hydrolysis. PVA is most widely used in the synthesis of poly (vinyl butyral) (PVB) and vinylon fibers. PVB is an ease flexible thermoplastic, being used as solid adhesive in multiple applications and may be used fit as a

fiddle memory devices. Vinylon is manmade heat and chemical resistant fiber (additionally called Juche fiber) fabricated from PVA and is widely used in textiles, blankets wadding, ropes, and shoes. Other consumers of PVA include the textile business, paper making, coatings, adhesives, medicines, optics, 3D printing, etc. The significant PVA producers are Europe, Japan, USA, and China. In 2016, worldwide creation of plastics and PVA was around 335 million metric tons and 1124 kilo metric tons, respectively. For the same year, commitment in PVA creation of Asia pacific and USA was around 580 and 172.8 kilo tons, respectively.

3. CHEMISTRY OF PVA

The monomeric structure of PVA was first synthesized in 1924 by Hermann and Haehnel by saponifying poly (vinyl ester) with sodium hydroxide solution resulting in a PVA solution. The physicochemical and mechanical attributes of PVA are governed by the number of hydroxyl bunches present in the PVA polymer. PVA is synthesized not by polymerization of its structural monomer (i.e., vinyl alcohol) due to its unstable

nature. For commercial creation of PVA, the fundamental crude material for the polymerization of PVA is vinyl acetate (as monomer). The controlled partial alkaline hydrolysis (saponification) of vinyl acetate is performed where the ester gathering of vinyl acetate is partially replaced with hydroxyl bunch in an environment of aqueous sodium hydroxide. The precipitate of this reaction is called PVA. The structure of vinyl alcohol and PVA is appeared in Figure 1. The time period length of the saponification reaction determines the degree of hydrolysis of PVA. PVA of low molecular mass is prepared by polymerization of acetaldehyde at low temperature of 2808C to 2208C with sodium blend. Based on hydrolysis (%) and molecular mass, different grades of PVA are available on the market having different characteristics including melting point, consistency, pH, refractive index, and band hole. The effect of variety in vinyl acetate length and degree of hydrolysis under acidic or alkaline conditions results in different congeners of PVA having different flexibility, tensile strength, dispersing power, emulsification index, adhesiveness, and dissolvability.

Parameters	Description
Molecular weight	20,000 to 400,000 g/mol
Structural formula	$(-\text{CH}_2\text{CHOH})_n-(\text{CH}_2\text{CHOCOCH}_3)_m$
Empirical formula	$(\text{C}_2\text{H}_4\text{O})_n(\text{C}_4\text{H}_6\text{O}_2)_m$
Partially hydrolyzed PVA	84.2%–89%
Moderately hydrolyzed PVA	92.2%–96.5%
Completely hydrolyzed PVA	98%–99%
Solubility	Soluble in water. Insoluble in aliphatic and aromatic hydrocarbons, oils, ketones, and esters

Figure 2: chemical properties of PVA

4. PHYSICS OF PVA

The physical attributes (density, crystallinity, film development, water solvency, molar volume, degree of polymerization, etc.) of PVA depend upon the degree of hydrolysis, gem precipitation, molecular mass and moisture. PVA is flexible, solid and hard, and possesses oxygen/fragrance

barrier properties. To prevent any PVA disturbance in gas permeability, moisture must be avoided. Physical adjustment of PVA is possible through crystallization process. The reason for PVA crystallization is due to hydrogen holding between PVA chains. When some exogenous nanoparticles (NPs) are introduced into the

polymer network, they go about as nucleating

agents during crystallization.

Physical property	Description	Physical property	Description
Appearance	Creamy to whitish, granular, powder	Melting point	230°C for fully hydrolyzed, 180°C–190°C for partially hydrolyzed
Bulk density	641 kg s/m ³	Boiling point	228°C
Density	1.19–1.31 g/cm ³	Thermal stability	Discoloration at ~100°C, darkens at above 150°C, decomposition at ~200°C
Specific gravity	1.3 (for partially hydrolyzed, highly viscous) [24]	Specific gravity	1.3 (for completely hydrolyzed, highly viscous) [24]
Stability to sunlight	Excellent	Glass transition temperature	75°C–85°C
Flammability	Burns like paper	Specific heat	1.5 J/(g K)

Figure 3: physical properties of PVA

5. NATIVE PROPERTIES OF PVA

The effect of increasing molecular mass of PVA include an increase in tensile strength, crystallinity, adhesion whereas flexibility decreases, consistency changes from low to high, the high dissolvability in organic solvent is changed into high aqueous dissolvability, the specific gravity increases from 1.19 to 1.31. The gem structure of PVA depends upon hydrogen holding patterns. Isotactic and syndiotactic PVAs exhibit an extended precious stone system and a helix gem structure, respectively; the steadiness of both the gem structures is due to hydrogen holding.

6. ESSENTIAL ADAPTATIONS OF PVA

The development of novel polymeric materials relies chiefly on aggravating, blending and alteration rather than chemical synthesis of a new polymer. PVA is an ideal grid for making flexible devices in electronics, optoelectronics, bioengineering, and different other fields due to its absence of harmfulness, biocompatibility, high hydrophilicity and easy processability. Hence, it is very critical to change PVA properties for different targeted applications. PVA can be modified chemically through the hydroxyl bunches on the backbone. Usually used conventional adjustment reactions include acetalization, carbamation, etherification, or esterification of the hydroxyl gatherings of PVA. The modern chemical alteration method might be click chemistry. The modified PVA material might be used in wide range of applications including molecular sensing, natural and biomedical, the membrane of fuel cells, chemo sensors, assimilation of harmful metals and

optoelectronic devices. Researchers prepared chemically modified PVA containing tosyl, azide, and amin functional gatherings that were attached to the carbon backbone. Different explanatory techniques were employed to affirm the presence of these chemical alterations. One significant problem in manufacturing polymeric Nano composites is uniform dispersion of nanofillers in polymer grid. Uniform dispersion assumes an imperative role in making multifunctional composites and could be achieved by exacerbating techniques. Aggravating means blending of different materials and these materials might be either mixture of additives–polymers or polymer–polymer. The resultant item might be a purported blend or composite. Generally, three types of intensifying techniques are observed including melt aggravating, in situ polymerization and solution blending. The PVA framework contains bountiful hydroxyl bunches attached to its carbon chain to permit other materials to be incorporated through hydrogen holding.

7. PVA NANOCOMPOSITES

A polymer composite comprises of reinforcing filler and polymer grid. The dimension of fillers might be in micrometer or in nanometer. A polymer composite delivers such properties that are absent in both filler and lattice. The joining of fillers can change the physicochemical properties of polymers. The type, size, shape, concentration, and common interaction have a solid effect on the modified polymer composite. Fillers might be of different sorts including metal powders, volcanic minerals, chalk, polymeric fibers, glass fibers, carbon fibers and furthermore common fibers. Fillers with nanodimensions are regarded as keen

dopant materials due to their extraordinary surface reactivity with polymers. Nanomaterials are ordinarily classified into 0, 1, 2, and 3 dimensions (D). The 0-D materials are as quantum specks, nanolenses, nano onions. The 1-D materials are found as nanowires, nanobelts, or nanotubes. The 2-D materials are found as nanosheets, nanoplates, nanodisks or nanowalls, whereas 3-D materials are found as nanocoils, nanocones, nanoballs, nanoflowers, or nanopillars. The blends of nanomaterials with polymers are known as polymer nanocomposites. Nanofillers (<5 wt%) are most widely used to enhance the properties of polymers including toughness, strength, modulus, heat and scratch resistance, dimensional dependability, thermal, and electrical conductivity due to their high aspect proportion. Nanofillers have advantage of possessing large surface area for interaction with encompassing lattice that is the key concept for the enhancement of the properties of polymeric nanomaterials. Moreover, nanofillers possess a quantum confinement effect which makes nanofiller-polymer interaction of great importance. Over the most recent 50 years, PVA has been a candidate material for diverse applications. PVA nanocomposites may include nanofillers made from metals, nonmetals, metal oxides, metal sulfides, inorganic, or mixes of these materials. Inorganic nanofillers may include carbon nanofibers, carbon nanotubes, muds, silicates and others. PVA is used as an embedding mat and grid for metal/inorganic nanofillers for sensing, designing of optoelectronic devices and numerous other applications.

8. PRACTICAL USES

8.1 Technological function

Polyvinyl alcohol has different applications in the food industries as an official and covering agent. It is a film covering agent specially in applications where moisture barrier/protection properties are required. As a component of tablet covering plans intended for items including food supplement tablets, Polyvinyl alcohol protects the active ingredients from moisture, oxygen and other environmental components, while

simultaneously veiling their taste and smell. It takes into account easy treatment of finished item and facilitates ingestion and gulping. The consistency of Polyvinyl alcohol takes into account the application of the Polyvinyl alcohol covering agents to tablets, capsules and other structures to which film coatings are regularly applied at relatively high solids contents.

8.2 Food categories and use levels

Polyvinyl alcohol might be used in high moisture nourishments so as to retain the overall good taste, texture and nature of the food sources. Confectionery items may likewise contain polyvinyl alcohol so as to preserve the integrity of the moisture sensitive constituents. Use levels for polyvinyl alcohol were developed by the support expecting the application of 2.3 mg PVA/cm² in aqueous film coatings. Most extreme use levels of polyvinyl alcohol were derived for the last nourishments by selecting items inside each food category with the greatest extent of moisture sensitive components, estimating the surface area of those components, and expecting covering of the entire surface area with polyvinyl alcohol.

9. CONCLUSION

Some possible issues in the developments of PVA nanocomposites may include: diversity in nanofiller types with multifunctionalities, increase in structural complexity, uniform dispersions, in depth understanding of interfacial interactions, and better command over synthesis steps with controlled morphologies. These issues require refinement of experimental techniques, boosting systematic methodology, and advanced specific knowledge. As a consequence, there may be progress in enabling huge advancement in industry and little medium enterprises. Hope the researchers will overcome the issues and favorable future of PVA composites can be expected. The market economy and entrepreneurship related to cutting edge PVAbased items will be stimulated.

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