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Evaluation of the Possilities for Cellulose Derivatives in Food Products

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Abstract

In this study, it was investigated evaluation possibilities of cellulose derivatives in food products. Wood is a very important natural source and one of the world's renewable resources as being very heterogeneous natural material which consists of mainly cellulose, non-cellulosic polysaccharides (hemicelluloses and pectin) and lignin. Cellulose is one of the popular food additives due to its unique chemical and physical properties when combined with water. Cellulose and its physical and chemical derivatives have been used in fabricating formulated foods for a long time. The physically modified celluloses are useful in many products where desirable bulk properties whichinclude reduced- or low-calorie foods, flavour oil imbiber or flow able products such as artificial sweeteners and flavour packets. Cellulose is also added to sauces for both thickening and emulsifying action. Cellulose derivatives in foods are used the regulation of rheological properties, emulsification, stabilization of foams, modification of ice crystal formation and water-binding capacity.

Key Words: Wood, Cellulose, Cellulose derivatives, Food

Gıda Ürünlerinde Selüloz Türevlerinin Değerlendirilme Olanakları

Özet

Bu çalışmada gıda ürünlerinde selüloz türevlerinin değerlendirilme olanakları incelenmiştir. Odun çok önemli bir doğal kaynaktır. Ayrıca dünyadaki yenilenebilir kaynaklardan birini teşkil etmektedir ve selüloz, selülozik olmayan polisakkaritler (hemiselüloz ve pektin) ve lignin gibi yapısal bileşenlerin bulunduğu heterojen doğal bir malzemedir. Selüloz, suyla birleştiği zaman özgün fiziksel ve kimyasal özelliklerinden dolayı uygun bir gıda katkı maddesi olmaktadır. Selüloz ve fiziksel ve kimyasal türevleri gıda imalatında uzun yıllardır kullanılmaktadır. Fiziksel olarak modifiye edilmiş selüloz, düşük kalorili yiyecekler, alkollü içeceklerde tatlandırıcı yada yapay tatlandırıcılar gibi toptan gıda özelliklerinin arzulandığı pek çok üründe kullanışlı olmaktadır. Selüloz hem yoğunlaştırma hem de emülsiyon reaksiyonlarına katılmaktadır. Gıdalardaki selüloz türevleri reolojik özelliklerin düzenlenmesinde, emülsiyonlaştırma, köpük stabilizasyonu, buz kristallerinin modifikasyonu ve su bağlama kapasitesinde kullanılmaktadır.

Anahtar Kelimeler: Odun, Selüloz, Selüloz türevleri, Gıda

Introduction

Since ancient eras, wood has been known an excellent source for food, energy for warmth, cooking, shelter, items and clothing. Wood includes cellulose, hemicellulose, lignin, extractives based on the classification of wood species (Margreate, 2012). The main structural component of wood is cellulose and forms nearly half of wood and other plant cells. Cellulose can be changed by chemical reactions to manufacture some products with its own especial characteristics, such as mouthfeel. The chemical modification of cellulose develops the chemical and physical features which allow to use in more applications in many sectors such as food production, biomedical, composites and personal cares (Labafzadeh, 2015). Achieved insoluble fibres from dilluted celluloses, like powdered cellulose and microcrystalline cellulose, are mainly used as an anticaking, dispersing and texturizing agent. Cellulose derivatives with low viscosity are given new features to food products and they can be implemented in many sectors. Furthermore, cellulose exists in cotton and vegetable biomass. It can be synthesised by algae and bacteria, too (Jacobs, 2015).

Reaction of wood

Abnormal environment or mechanical and physical stress on a tree can cause abnormal wood formations. The reaction wood is tried by the tree to return the trunk or limps to more natural position in which there is a reaction wood kenned as compression wood for soft wood. It is in the lower side of the limp or skewed trunk and manufactures wood cells with high phenol lignin and low carbohydrates. Chemical, physical, anatomical and mechanical properties of reaction wood are varied from those features mentined above. Some examples of these properties provide higher cell wall, higher density and higher compression strength in reaction wood than normal wood whereas higher gravity in compression wood than normal wood (Margreate, 2012).

Wood chemistry

Wood is formed by cellulose, non-cellulosic polysaccharides (hemicelluloses and pectin's) and lignin. The structural of constituents is a very heterogeneous being 97– 99% natural material. The polysaccharides are arrayed in four structures from linear to highly furcate. Structural polysaccharides are considerable heterogeneous, involving slight modifications of the recurrent unit. Attached to the structure, the extractives in wood which include a abundant range of low-molecular-mass substances like resin, fats, phenols and carbohydrates are non-structural compounds as widespread. Some extractives are energy resources for the wood cells and participate in the catalysis of biosynthetic periods. The extractives in wood are approximately 3 – 5%, however, the content might change based on wood types, various parts of the wood, and even at various seasons (Margreate, 2012). Moreover, extractives can conserve wood against microbiological harms or attacks by herbivores.

Table 1. Typical compositions of hardwood and softwood (Fengel and Wegener, 1979)

Compound	Hardwood (%)	Softwood (%)
Cellulose	45±2 %	42±2 %
Hemicellulose	30±5 %	27±2 %
Lignin	20±4 %	28±3 %
Extractives	5±3 %	3±2 %

Cellulose

Cotton and wood are the significant resources of cellulose about 94% and 50% respectively to manufacture paper, textiles, construction materials, cardboard and cellulose derivatives such as cellophane, rayon, cellulose acetate (Sherif, 2014). Cellulose competes only with chitin with regards to abundant. It has been predicted that cellulose prefered in industry for the production of paper, mining, building and allied industries and as a resource of bioenergy synthesizes changes from 100 to 1000 billion metric tons every year. The main source of processed cellulose is wood pulp which produce the paper over 3 million tons, into reinvented fibres and films or chemical derivatives (Stephen et al. 2006).

Occurrence and structure

Cellulose is the main structure of plants and composes 90% of the cotton fibres, 40-50% of the wood and 80% of flax besides green algae which have cellulose in their cell wall (Marchessault and Sundararajan, 1983). The cellulose consists of polymer of thousands β(1→4) D-glucose units. One end of chain has decreasing group and other end has a non-decreasing group (Xuan, 2014). Cellulose is a polysaccharide which is 45-50% of the wood's dry weight and nearly 5×10^{11} metric tonnes of cellulose are biosynthesized yearly, whose 2%

is utilized as industrial (Xuan, 2014).

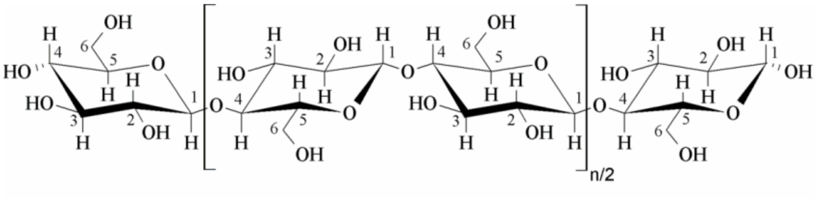


Figure 1. The structure of cellulose polymer (URL-1)

Chemically modified cellulose derivatives

Cellulose derivatives have capability to subserve as emulsifiers, colloidal stabilizers, usage in the pharmaceutical and food industry owing to their non-toxic nature for a long time (Nilsson et al. 1995).

Dextran is used directly in pharmaceutical manufacturing and in medicine to illustrate as an alternative to plasma. Applications of some sugars such as carrageenan is similar to cellulose derivatives. Hyaluronic acid has a large significance for medical usages. At that in a solid or semi-solid image, it was determined that cellulose and cellulose derivatives use as absorbents in organizing the release of films widely (Graenacher, 1934).

Although the broad variety of cellulose derivatives have been obtained, especially acetate and nitrate esters (Klemm et al. 2005; Einfeldt et al. 2005), cellulose ethers (Majewicz and Polas, 1993; Murray, 2000) and sodium CMC (sodium carboxy methyl cellulose) are the most widely used cellulose derivatives for foodstuffs. Because of their unique and interesting properties, other ethers are used in various products. For instance, methylcellulose (MC) and hydroxypropylmethylcellulose (HPMC) can form gels on heating. Due to their availability, easy handling, stabilization, water retention and film formation low toxicity and great variety of types, a number of cellulose ethers are utilized from effects of flow control and economic efficiency. There is a large distribution in the worldwide market of cellulose ethers such as carboxymethyl cellulose (CMC), hydroxypropyl cellulose (HPC), ethyl cellulose (EC), methylcellulose (MC), hydroxyethylcellulose (HEC), hydroxypropylmethylcellulose (HPMC), carboxymethylhydroxyethylcellulose (CMHEC) (Ragab, 2012).

For preparation of cellulose derivatives, it is paid regard to that mercerization is the first step as activation in the etherification of cellulose. The first reaction is named Williamson Ether Reaction and contribution of an alkyl to the cellulose. The second reaction is a base-catalysed oxalkylation where the activated hydroxyl groups are replaced to alkaline oxide groups. This neutralization is conducted with a weak acid for manufacturing water and salt formation. NaCl is generally preferred since NaOH is the most commonly used material in mercerization. In addition, a purification step is conducted to refine the product. Ether derivatives demonstrate that the derivatives are more soluble in water, biodegradable, reactive and possibly they display same safety as cellulose. HEC (hydroxyethylcellulose) and CMC (carboxymethylcellulose) are examples of varied products. HEC is composed as soon as alkali cellulose has been reacted with ethylene oxide. Provided that the HEC is reacted with ethyl chloride, it results in EHEC (ethylhydroxyethylcellulose). Provided that cellulose reacts with monochloroacetic acid, CMC is constituted (Wikström, 2014). Classical reactions are especially esterification, etherification and oxidation reactions. Esterification is reaction of cellulose with an favorable acid anhydride or acid chloride. Cellulose etherification can be performed by three main routes, that is 1) by the Williamson ether synthesis with alkyl halides in the existence of a hard base, 2) with alkylene oxides in a powerless main medium, or 3) by

Michael addition of acrylic or corcerning unsaturated constituents, such as acrylonitrile (Klemm et al. 1998; Klemm et al. 2005)

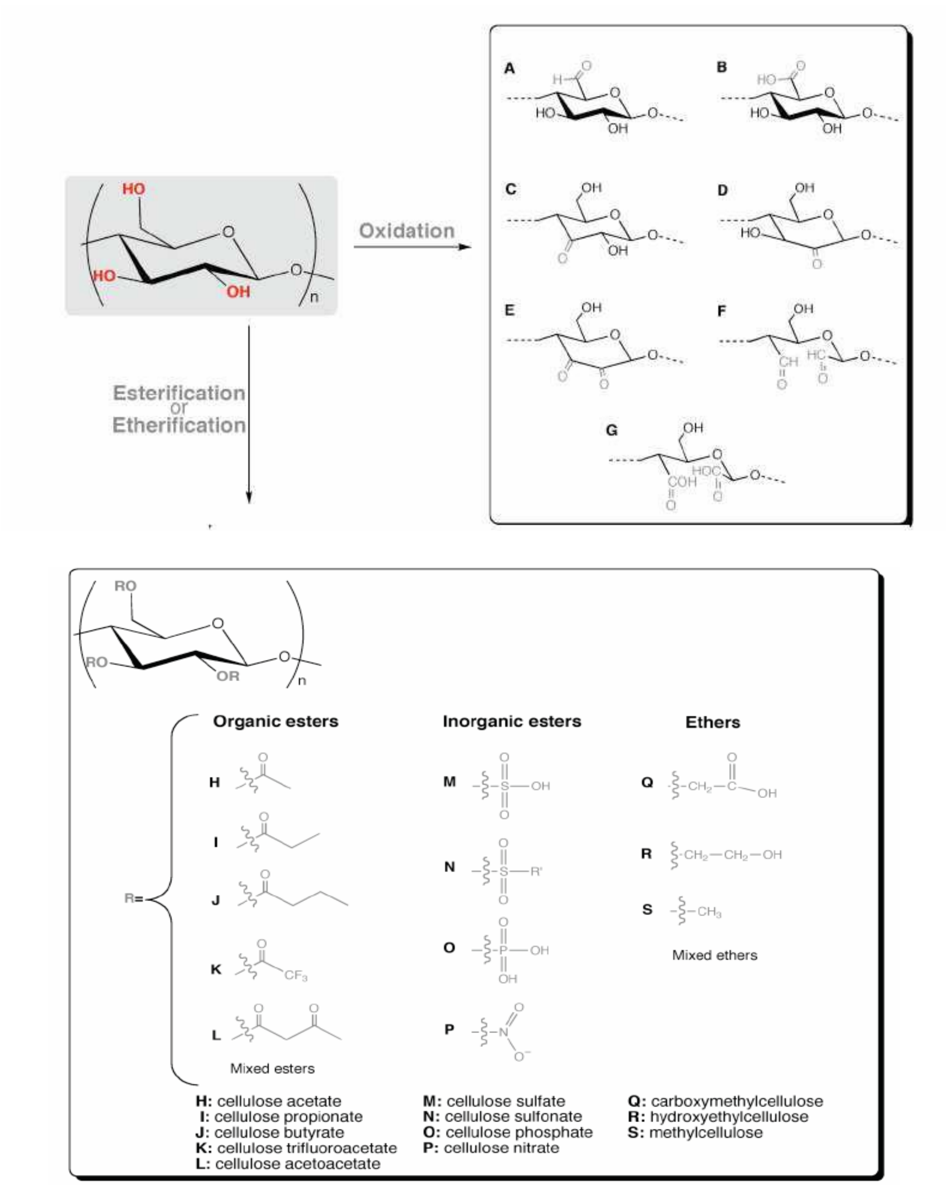


Figure 2. Schematic representation of the main types of cellulose chemical modification and some of the typical ensuing products (Klemm et al. 2005)

Sodium carboxymethylcellulose (CMC)

CMC which is anionic, linear and soluble polymer in water can be seemed as free acid or sodium salt, or mixtures. Sodium salt is one of the most widespread food materials which is used to imply CMC sodium. In United States, it is frequently used as "cellulose gum" in food grade CMC. CMC hinges on DS (degree of substitution) of the hydroxyl group, which is contained in the reaction in return for the replacement of cellulose, naivete, crystalline and molecular weight (Mohammed et al. 2014).

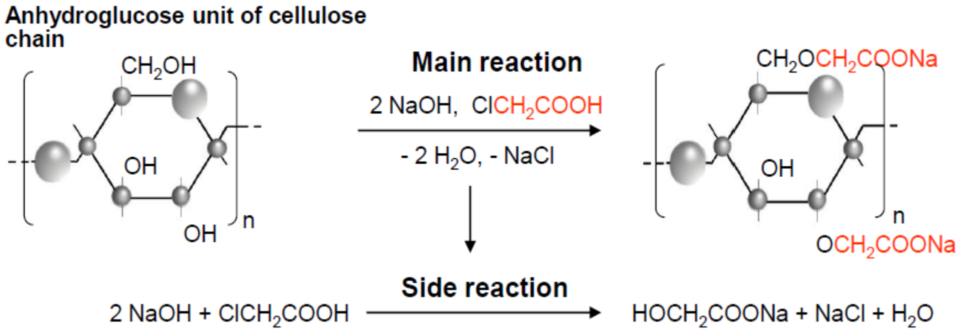
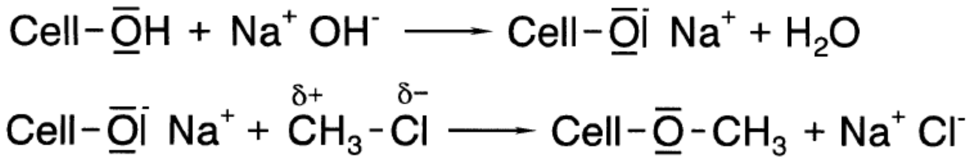


Figure 3. A substitution reaction of monochloroacetic acid to alkoxy cellulose (Konttur, 2014)

Methylcellulose (MC)

MC is used for cellulose ether family who replace with or without methyl plusage functional alternatives. This category involves hydroxyethyl methylcellulose (HEMC), which is permitted in the European Economic Community (EEC) and hydroxypropyl methyl cellulose (HPMC). MC was first identified as a cellulose ether in 1905. The interpreters described MC as alternative in the proportion of FCC (Food Chemicals Codex) (Anon.1966). Favorableness of these esters, cellulose non-ionic based primarily on four main adscriptions are: 1) the thickness of efficiency and activity of surface, 2) the ability to shape a film, 3) perhaps of great substance food art and 4) the capability to mold a thermal gels which melt on cooling these methylsamples. The main physical features are specific and gelation led by high temperature gravity, surface activity in the air/water interfaces and adsorption at the solid/water interfaces (Pauline et al. 2015). The MC uses in the food and pharmaceutical industries widely owing to its characteristics such as perfect film forming capability, fat barrier function, low oxygen and dampness vapour conduction ratio. Furthermore, it has some supplement features as a thickener, glue-proof, aid agent emulsification and a binder or film covering/formation of various doses agent attributing interest on a big level in the fields of medicine. MC displays a crystallized form at temperatures ranging from 60-80ºC. Some studies indicated that the proportion of gelation and the strength of the gel in MC depended on the molecular weight (Sonam et al. 2013).



$$\mathrm{Cell}-\overline{\underline{O}}\mathrm{H} + \mathrm{Na}^{+}\,\mathrm{OH}^{-} \longrightarrow \mathrm{Cell}-\overline{\underline{O}}|^{-}\,\mathrm{Na}^{+} + \mathrm{H_2O}$$

$$\mathrm{Cell}-\overline{\underline{O}}|^{-}\,\mathrm{Na}^{+} + \overset{\delta+}{\mathrm{C}}\mathrm{H_3}-\overset{\delta-}{\mathrm{Cl}} \longrightarrow \mathrm{Cell}-\overline{\underline{O}}-\mathrm{CH_3} + \mathrm{Na}^{+}\,\mathrm{Cl}^{-}$$

Figure 4. Conventional preparation by Williamson Ether Reaction with gaseous or liquid chloromethane (SN2 type nucleophilic substitution) 40% NaOH used in the industrial procedure for heterogeneous reaction (Konttur, 2014)

Methylcellulose is identified in food procedure in many countries in the world. It is recognized as an emulsifier to hinder separation of two mixed liquids and texturing ingredients coded by E461 in the European Community. Besides, it is thought as a thickening and gelling additive. Such as cellulose, it is non-digestible, non-toxic and non-allergic. The texturing factor of MC was used particularly in bakery products to achive certain size and texture, to develop the viridity of pastes and to produce gluten-free products.

MC assists to hold the shape and properties of gelling temperature and also decreases the fat pick-up once frying frozen products like extruded croquettes, (Pauline et al. 2015).

Ethylmethylcellulose (EMC)

Only one vendor in worldwide, produces ethyl methyl cellulose (EMC) (Anon. 1981; Coffey et al. 1995). Product has an ethyl DS 0.3 and methyl DS 0.7, in which the properties of rheology and salt tolerance, stability and pH were conformed by MC. Nonetheless, instead of gelling, EMC joins aqueous solution as soon as it heats above 60ºC and re-solution happens on cooling (Coffey et al. 1995).

Hydroxypropylcellulose (HPC)

This product is composed by two manufacturers in the quality of HPC and it is present in six viscosity grades (Coffey et al. 1995). This ether displays a large surface activity and has no gel thermally, but it deposits as an aqueous solution above 458ºC. Besides, HPC tolerance indicates a marked decline on the dissolved electrolytes. Hence, while the MC, CMC, and HPMC are all soluble in 10% of the aqueous sodium chloride solution, HPC is insoluble. It has been known that HPC shows more solubility than any MC or HPMC in polar organic solvents (Anon. 1981).

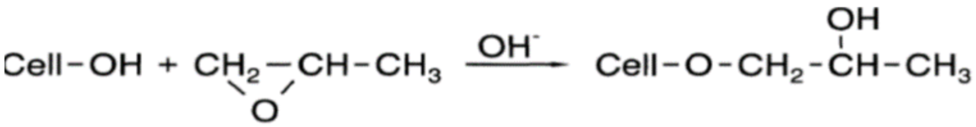


Figure 5. The structure of hydroxypropylcellulose

Synthesis of cellulose derivatives

It is known that reactions defined in the studies published are on the basis of the types of reaction (acylation etc.). Most researchers have concentrated on only the synthesis of cellulose derivatives, but it has been overlooked physical characteristics of the derivatives that were achieved. The researchers also focused on defined DS values of derivatives and this is a very significant factor. Nonetheless, the area of the new synthetic approaches is implemented to the cellulose in ionic media reply liquid reaction lacks empirical data. In some cases, the ionic liquid can supply more interactive or consistent for certain feedback environment. Cellulose is a multiple inception material for many applications. It is directly associated with the paper industry, in which cellulose is used as a traditional way in the production of structural paper and cardboard products. Nevertheless, despite this current major usage of cellulose, the imagination is the limit for the usage of this as versatile and adaptable to material extremely. Cellulose can be modified as chemical to produce derivatives which are widely used in various industrial sectors in addition to traditional applications (Graenacher, 1934). To illustrate, in 2003, it was used 3.2 million tons of cellulose as a raw material in fibres obtaining and films were remade in addition to the production of cellulose derivatives. Derivatives are used for the coating, lamination, optical films and absorbent materials. In addition, the cellulose derivatives can be found on the additives in building materials and also in the pharmaceutical, food and cosmetics. Table 2 shows the usage of cellulose derivatives in and applied sectors (Klemm et al. 2005).

Table 2. Commercially important cellulose esters and ethers (Swatloski et al. 2002)

Product	**Global Production (t/a)**	**FG**	**DS (Degree of Substitution)**	**Solubility**	**Application**
Cellulose acetate	900000	-OAc	0.6-0.9 1.2-1.8 2.2-2.7 2.8-3.0	Water 2-methoxy ethanol Acetone Chloroform	Coatings and mebranes
Cellulose nitrate	200000	$-NO_2$	1.8-2.0 2.0-2.3 2.2-2.8	Ethanol Methanol, acetone Acetone	Membranes and explosives
Cellulose xanthate	32000000	-C(S)SNa	0.5-0.6	NaOH/water	Textiles
Carboxymethyl cellulose	300000	$-CH_2COONa$	0.5-2.9	Water	Coatings, paints, adhesives and pharmaceuticals
Methyl cellulose	150000	$-CH_3$	0.4-0.6 1.3-2.6 2.5-3.0	4% aq. NaOH Cold water Organic solvents	Films, textiles, food and tobacco industry
Ethyl cellulose	4000	$-CH_2CH_3$	0.5-0.7 0.8-1.7 2.3-2.6	4% aq. NaOH Cold water Organic solvents	Pharmaceutical industry
Hyroxylethyl cellulose	50000	$-CH_2CH_2OH$	0.1-0.5 0.6-1.5	4% aq. NaOH Water	Paints, coatings, films and cosmetics

Esterification of cellulose

N-alkylpyridinium halides, notedly N-ethylpyridinium chloride and N-benzylpyridinium chloride, are prefered in the esterification of cellulose as the first ionic liquid. These solvents have high melting points. Thus they are diluted with organic solvents, such as DMSO, DMF or pyridine. These mixtures provide a response to homogeneous reaction used several carboxylic acid derivatives or two compounds like acid chloride and pyridine as a base. These derivatives contain acetate, butyrate, benzoate, phthalates and anthracitic acid esters of cellulose, but due to DS, values of mentioned these derivatives to judge the competence of these reactions is difficult (Wu et al. 2004).

Acetylation of cellulose

It has been studied acetylation of cellulose in different ionic liquids widely. This reaction was conducted in the existence of base or without usage of acetic anhydride or acetic chloride as reagents. Ionic liquids were found both as solvents and catalysts and as an active base for the acetylation reaction to work (Lewin, 2006). Commercially the production of cellulose acetate is a reaction of cellulose with an excess of acetic anhydride in the presence of sulfuric acid or perchloric acid as a catalyst. Due to the fact that nature of the reaction is homogeneous, it is impossible to manufacture relatively acetylated cellulose directly. Conversely, acetylation of cellulose in the ionic liquid produces derivatives with different values with regard to control DS. Moreover, when it is used as reaction media ionic liquid and it can lessen the amounts of chemicals. There is no need to do a catalyst. Besides this leads to it easier to recycle solvents and achievable (Lewin, 2006; Wang et al. 2008).

Sulphation of cellulose

This reaction is mainly in sulphate job categories that they have a high density poly activity anionic heparin effective treatment for clot and anti-clotting agents. In addition, owing to fears of heparin with animal origin and increasing of desires for low-cost, non-animal origin materials are new analogues for bio-sourced. Cellulose sulphate has structures β-1,4-glucan sulphate which is very similar to heparin in sulphated glycan structure and thus it can be considered as a potential source of heparin analogues (Zugenmaier et al 1999; Mormann and Kucketz, 2002).

Carbanilation of cellulose

Cellulose tricarbanilates and reported various functional groups in the aromatic rings can be prefered to dissever the enantiomers (Yashima et al. 1995; Barthel and Heinz, 2006; Schlufter et al. 2006).

MCC was conducted with cotton linters, pulp and bacterial cellulose (BC) in [Bmim]Cl (Terbojevich et al. 1995). Carbanilation process from cellulose sources are used with cellulose including low and high DP. Furthermore, this process has been made in homogeneous conditions with DMA / LiCl formerly (Myllymäki and Aksela, 2005). In [Bmim] solution of chlorine in cellulose carbanitrile reaction was found between 0.26 and 3.0 DS regardless of the DP and the source of cellulose. However, with high DP cellulose hemicelluloses have low interaction and because of this long reaction times required much amounts of reagents. It is explained with variations of interaction between sources of cellulose and presence of hemicellulose in the pulp. Solubility of products changes according to DS values and when DS> 2.4, these materials soluble in DMSO, DMF and THF exactly. (Terbojevich et al 1995; Heinz et al. 2005)

Carboxymethylation, ethylation and propylation

First time Myllymäki and Aksela described carboxymethylation of cellulose in a wide range of ionic liquids in a patent (Heinz et al. 1999). Carboxymethylation of cellulose in [Bmim] chlorine was done with DMSO by diluting of cellulose-IL to obtain a proper mixing (Mikkola et al. 2007). It was added to a solution of sodium hydroxide and sodium mono chloroacetate dissolved in DMSO solution. For obtained carboxymethyl cellulose (CMC) with DS 0.49, equation 1:1 was used. Despite the reaction in ionic liquids, carboxymethylation of cellulose in traditional solvent systems which are Ni(tren)OH_2, NMMO and $LiClO_4 \cdot 3H_2O$ continues with higher values DS (Helferich and Coaster, 1924). Carboxyethylation and propylation of cellulose in [Bmim] Cl and in Amim] chlorine have been practised, but the reactions concluded in a lower DS values (Hearon et al. 1943).

Tritylation

Tritylation of cellulose is transpired reaction which manufactures regioselectively of C-6 substituted cellulose derivatives positions diverge the C-2 and C-3 existing for next corrections. Regioselectively replaced cellulose derivatives and grew interest owing to its inimitable properties in comparison to their counterparts (Graenacher, 1934; Dawsey and McCormick, 1990; Camacho et al. 1996; Myllymäki and Aksela, 2005).

The reactions with ionic liquids in tritylation were performed in molten salts by using pyridine as a solvent and or inorganic base (Swatloski et al. 2002; Erdmenger et al. 2007). It was researched tritylation of cellulose using [Bmim] as a means of chlorine reaction with triphenylmethyl chloride (trityl chloride, TrCl) in the presence of pyridine. The base in the reaction is very important. Failing that, the reaction led to a significant degradation of cellulose. Furthermore, it was noted that once pyridine was used, long reaction time (ie 24H) led to extensive decomposition of the cellulose in 100°C (Swatloski et al. 2002). This problem was bewared by reducing the reaction time to 14 hours, owing to the fact that the influence of the reaction temperature did not work. Observed situation was in shorter reaction times (or 1 or 3 H), DS is nearly 1 for production sufficiently. This result indicates an advantage for conventional DMA / LiCl solvent system according to achieved similar values DS within 24 hours reaction. Moreover, tritylation has been explored as a base triethylamine (Erdmenger et al. 2007).

Applications in foods

It has been used cellulose and its derivatives in the manufacture of processed foods since a long time. Moreover, physically modified celluloses are beneficial in many products where especially bulk properties This contains reduced or low-calorie foods, the flow of products capable of such unnatural sweeteners and flavour packets and also imbibers’ oil flavour. This is the usage of cellulosic generally owing to the rheology and the interaction of water controlled, textural qualities and some chemical characteristics. Eventually, MCC and soft cellulose land values play a role in bulking low-calorie foods. Five important roles of the chemically modified cellulose derivatives in food industry are to organize the flow properties, emulsification, and the stability of the foam, and modification of ice crystal formation, growth and the ability to bind water. The applicability of the cellulose derivatives of certain food applications can be chosen with respect to physical and chemical characteristics. When the choice makes, it must be considered in several parameters: (a) the chemical compound of the polymer, (b) molecular weight of the polymer, (c) the presence of other active additives in the food matrix, (d) food production process and (e) the physical properties, including the polymer fibre sizes. Many opportunities and application areas have arisen lately (Setser and Racette, 1992).

Fish/Meat

Protein-based foods often need stabilizers to advance the shelf-life during ambient or frozen storage. These products can maintain their structural integrity during storage, but some chemical materials can be added to the chewing gum to provide and to advance the quality of products. Seafood producers can be utilized from cellulose derivatives to allow manufacturing of a novel and precious seafood products. It may be produced extruded shrimp or fish nuggets to benefit from these products anymore.

Trends in the industry it is thought as to reveal new opportunities by decreasing the fat content of meat to enhance the consumer diet more healthy with regards to cellulosic. Especially, the formation of film with feature attributes interfacially with active MCS. It provides the ability to simulate the texture of fat in these fat-reduced systems. It can be a good coating for eating to improve the fresh quality of frozen and processed meat, poultry and seafood products. The reduction of fat oxidation and discoloration improve the appearance of the products in retail packages by eliminating dripping and sealing in flavors volatile. Furthermore it works as supports of food additives such as antimicrobial agents and antioxidant (Khan et al. 2013).

More advantage of usage a thermally gelling cellulosic is the production of a comparatively oil-insoluble barrier during frying. MC and HPMC constitute a water holding gel that inhibits oil access during frying, with a reduction of up to 50% oil absorption (Stephen et al. 2006).

Sauces, gravies, soups, drinks

Plenty of liquid food products such as sauces, gravies, soups and juices are manufactured with hydrocolloids including cellulose derivatives. Modified celluloses can aid to continue structural collectivity during freezing. Besides, they can significantly diminish the calories of food by replacing carbohydrates or fat. Cellulose derivatives are frequently prefered in these products to upgrade the competence of water binding and minimise the problem of syneresis on disintegration. They can supply viscosity in systems including decreased levels of fats and oils. Besides, the usage of certain cellulose ethers in coupling with other stabilizers and emulsifiers in liquids consisting of fat systems. The talent of cellulose ether such as HPC, HPMC and MC is important in many of these products to gather at oil droplet interfaces and to hinder oil droplet association. In addition this, sauces and gravy contain carbohydrates to ensure bulk viscosity and wished sensory characteristics. Filled juices, particularly low-calorie products, can be a good usage of cellulosics. Application of carboxymethyl cellulose and carrageenan in chocolate drink progresses the viscosity and consistency of product. but it doesn’t occasion important differences in the physicochemical properties. Moreover, with rise of stabilizer viscosity develops since 2% carboxymethyl cellulose and 1% carrageenan indicate the maximum viscosity. According to the results, it was determined that the level of 0.5% carrageenan and 1% carboxymethyl cellulose in respect of rheological and sensory properties more admissible than other samples which is the best treatments CMC ineffective provision in these applications. Thickener in the systems that the concentration of dissolved solids is very high (45-60%) manufactures translucent solutions. The materials such as sauces, gravy and stuffing cream soup take advantage to control the viscosity (Marzieh et al. 2015).

Emulsions

Salad dressings and whipped toppings are in the emulsified food group, first is oil-in-water emulsions and second is foams of oil-in-water emulsions. Both kinds need specific basic chemical and physical properties that are acquirable with usage of cellulose derivatives. In general, oil and water emulsions with oil concentration ranging from 10 to 50% are preferred for preparing pourable salad dressings. In these systems it is significant to inhibit flocculation and coalescence of oil which is dropped swiftly. Cellulose ethers promote the fixity of the emulsion by focusing on the oil-water interface and it provides a barrier of hydrated polymer for every tass. In the low-calorie salad dressings, imitation the mouth feel of higher oil dressings can be a major drawback to the fixity of low oil. Cellulose derivatives can be active on the surface to supply the formation of the film and to remove chemical properties of oils. In addition this, they can develop the viscosity of these products. Dried salad dressings cause troubles for food formulators. In these products, dry mixture of stabilizers packs, spices and flavours should sell by packaging to clients.

The consumer is the last person which will use the products. These products should be formulized easily and they should be proper for daily use. The usage of HPMC and MC is profitable since it ensures fast hydration and emulsification with regard to encountered low gliding in the home setting. Fast interface translocation of cellulose ethers provide the stabilization of the emulsion swiftly and ease of handling for the consumer. In general, the products like whipped topping have an additional storage burden since they have to keep alive as frozen storage. In this situation, the usage of cellulose derivatives can diminish syneresis which is a sharp fault, during iterative freeze–thaw cycling. Cellulosic has often been used in emulsion of food products. Most commonly, salad dressings emulsions are prepared with HPMC and MCC. HPMC is included in the mixture as an emulsifier, rheology controller and developer the sensory properties. Owing to the fact that HPMC is a surface-active material, it moves to oil droplet–water interface and put a barrier for water in the front of the polymer. This process hinders the coalescence of oil drops and the subsequent surface evolution. Besides, as the ingredients gather at the droplet interface and they inhibits large droplets from formation, the refractive index of the droplet modifys and the colour is lighter than tone. It is thought that this situation is a benefit in creamy dressings. Ultimately, HPMC enhances the viscosity of the product and organoleptic properties, recuperating the otherwise funicular mouth sense and gelatinous view of casting dressings. In spite of their task in casting dressings as surfactants, cellulosics can be utilized in high-viscosity. MCC helps in the manufacture of products and reduce the full-time calories by raising the viscosity of the progressing fracture phase. Besides it promotes the larger installations cut calories (Stephen et al. 2006).

Baked goods

Cellulose and cellulose derivatives are preferred in the manufacturing of baked products recently owing to their profitable. Bread needs a specific size value to have the formation of a good the cell structure, a fine texture and high eating standard. Typical white bread attains more than the size of the training and the quality of gluten which is a protein the most plenty of wheat flour. Nevertheless, selection of different quality and quantity of in usage of varied wheat flour influence qualifications of the product. Additives have been utilized to correct this situation. In general, the foods with high-fiber, variety of diet breads, buns, and rolls include diminished quantities of flour by way of extenuated the caloric value. Consequently, they need specific readjusting to supply nut structure and baked quality for comparable to products containing wheat flour. Breads with high-fiber provide usage of various cellulose derivatives. Altered products like MCC or other cellulose derivatives are managed as a fractional substitution for wheat flour and some of the foodstuff energy of the flour. Ordinarily modified celluloses have little performance in baked goods. Hence, specific constituents have to be modified to yield in obtaining a product of suitable qualification. Dough rheology is influenced once chanced celluloses substitute part of the flour due to the water requirement and mixing qualities changes. The baking qualities of decreased wheat flour breads are generally worthless and it have to be reimbursed for by other agents (Stephen et al. 2006).

Sour dough (spontaneously) in 4 levels of 0, 10, 20, 30 percent as the natural protectives and hydroxylpropylmethyl cellulose gum in 3 levels of 0, 1/5 and 3 percent are prefered and their effects on dough rheological characterizations and bread's properties were researched. It is specified by the dynamics characteristics of aerobic dough (dough stability, the needed time for the improvement of the dough, water absorption and several calorimetry) with Farinograph. The results indicate that the rise of density of this gum causes to augmentation of viscosity, dough fixity and the absorption of flour in water. The rise in this gum's density leads to the wane of solidity and gumlike properties of the bread which demonstrates the raise of bread's quality. Thus, hydroxylpropylmethyl cellulose gum is utilized as an favorable agents to advance the quality of bread (Rahdar et al. 2014). The usage of MC and HPMC parries the serviceableness lost of bread owing to the lowered concentration of wheat flour. They ensure an elastic mass during tightness and baking that traps with CO_2 and permits maintaining volüme of bread satisfyingly. For these breads patents have been achieved and they are subsistence in the U.S as trade largely. In the structure of breads and rolls, gelling derivatives are very beneficial thermally. Because MC and HPMC are interfacially active and they can be moulded with elastic gels at raised temperatures. They can be implemented to added dough strength and similarity through make-up, proofing, and baking. Furthermore they cause coherent oddments structure in the last baked product (Bell, 1990). With together heat the features of surface activity and gelation multiply with regards to damp retention and tolerance to the changing environmental conditions nowadays. These situations advance the manufacturing of bread which is made from ordinary wheat flours as well as baked goods with very low wheat protein levels or especial breads produced from other grains like rice and barley which include gluten and 3% cellulose or cellulose derivatives (Hart et al. 1970; Nishita et al. 1976). Cellulosic's can be managed as intumescency ingredients in the manufacturing of high-fiber breads. As cellulose is a indigestible material, the physically changed derivatives can easily be used at significant and high concentrations as a complement fiber source for sweet baked foods, such as cakes. Moreover they can be developed by the participating of cellulosics in spite of at lower levels. The foods like bread and cakes require certain flexibility and structural aggregateness. By means of thermal gelling cellulosics can conduct better acquires of these needs. Rised cake bulks have been indicated with MC, HPMC, CMC and stimulated CMC through a viscosity quality. Cake heights have been sighted with the usage of HPMC and MC. In the sensory evaluations related with this researches, textures were described as humid without extreme chewy. Besides cellulosics play a role in developing of the texture of diminished-fat cakes by supplying butter thickening, moisture seising and film-designing characteristics in these products (Garcia et al. 2002; Naruenartwongsakul et al. 2004).

Frozen desserts

Frozen desserts often contain hydrocolloids such as cellulosics, gelatins, starches, and carrageenans. The cellulosics are utilised to control ice crystal accrual and to shift rheology (Towle, 1996). A few formulations which involve different cellulosic materials are present. . Particularly, this is true for several frozen products that have advantage like both to change rheology and to supplement air. Frozen dessert industry displays a trend toward replacing fat in food systems. Cellulose derivatives can manufacture textures in low-fat or fat-free frozen desserts that are congruence to the mouth feel related to products including higher fat levels. For instance, in ice-cream and other deep-frozen products, MC lessens the ice crystal accrual during freezing and melting. In mayonnaise, spices, creams and sauces, MC permits viscosity emulsion fixity and control and it decrease the range of fat and eggs. Consequently, MC has been advised for food products such as low-calorie, low-fat and non-digestibility. In addition, MC is evaluated to acquire foam in cold drinks or to progress a homogeneous disintegration of the various agents in food products (Pauline et al. 2015).

Fried foods

MC and HPMC are prefered in formalised foods, like improved onion rings and to sustain the shape of products during frying. In addition to this, they are used to add texture for a tasteful eating once the product is warm. Moreover MC and HPMC are exploited in plump paste to hinder boil-out during baking or frying. MC types are detected to be most proper for batters of fried foods because of lower gelling temperature and natural powerful gelling of methyl cellulose. Into the bargain batter viscosity will affect fat increment during frying. A higher viscosity ends up better batter coatings and lower oil penetration, hence high viscosity of kinds of MC types might be beneficial in this area. In dried batter mixtures, MC hydrates are more soluble in cold water than in hot water (Imeson, 2010).

Evaluation of cellulose derivatives in food processing

Nutritional effects

Some food constituent can influence the dietary density or quality of the diet in several ways. The most apparentness is nutritious ingredients of a food. An instance of this is the usage of vitamins and minerals to promote ready-to-eat grains. Secondly, it is that without functional additive food could not be manufactured, apportioned or adopted by consumers. CMC addition to ice cream develops the mouth feel and diminishs the accrual of ice crystals during frozen holding. Besides, an ingredient might have an effect on the foodstuff density of foods as a nonnutrient substitution, lowering the caloric burden and making a wider kind of products present to consumers. For instance they are the usage of gums in the formulation of low-oil salad dressings and cellulose in making of low-calorie breads. Neither of the cellulosics are precious as foodstuff sources as people lack required digestive enzymes to ingender the β-1,4-linked glucose monomers. They are the corner stone for much of beneficialnesses of these products in food which plays role cellulose and its derivatives significantly. To illustrate the usage of CMC supplys to maintain first quality of ice cream during frozen holding than control samples. This operational role is vital to modern manufacture and delivery systems. At last, it allows more efficient usage of raw materials, springiness in handling and storage and preservation of food resources. Physically modified celluloses are particularly significant since bulking ingredients in changed foods, cellulose flours and MCC are largely utilized as fractional substitution for flour and else nutrition materials in breads and any desserts (Stephen et al. 2006).

Dietary fiber

Some researchers and relevant lookerons identify dietary fiber as ingested material which is stubborn to digestion in the gastrointestinal place of humans.

The constituents which include dietary fiber are cellulose, hemicelluloses, lignin's, pectin's, gums, mucilage's, waxes, monopolysaccharides and indigestible proteins. As chemical modified cellulosics like CMC, MC, HPMC, HPC and EMC which are indigestible but soluble can put to similar group. There are two kinds of dietary fiber: soluble and insoluble. The insoluble materials shape a voluminous mass and rapid transit time through the gastrointestinal zone because of their contents. Cellulose, hemicelluloses, and take part in this group in order that cellulose flour, MCC and MFC are involved, too. The pectins, gums, natural and modified mucilages are found in the soluble dietary fibers. All of them have the competency to keep water. Attendantly, they augment the viscosity of the food bolus. Erstwhile, soluble dietary fiber was restricted as vegetable origin like Arabic gum, guar gum, and locust bean gum which are common to many people, yet nowadays there is a large admittance of the implication of celluloses as chemical modified in this class. Whole gums raise the water content of the stool, nonetheless they may perform in varied ways.

All of the natural gums which is not basic on β-1,4-glucan backbones are fermented to a outstanding degree. Hence they mislaid their inherent water-binding talent and they prop high bacterial cell contents in the stool. The raised bacterial cell volume leads to approximately 80% water and resistant to dehydration (Ink and Hurt, 1987). Conversely, the water-soluble cellulosics are stubborn to digestion and they maintain their molecular aggregateness and water-binding knack even in the colon. Thus, the raised moisture content in the stool related to derivative cellulosic's is a significant issue owing to the water of hydration of the polymers. There is a useful dietary influence seeing that the proportion of diffusion of glucose is diminished in the presence of viscous fibers like MC (Marthinsen and Fleming, 1982; Augustin et al. 2002).

Water-holding capacity

Cellulose and its derivatives diversify in their water-holding capacity largely. On the whole cellulose and its derivatives are inclined to imbibe a little water due to their relative insolubility and they are apt to conglomerate together with strong hydrogen bonding. On the other part, modified celluloses as chemical are soluble in water in consequence of the addition of replacement groups such as methyl, carboxymethyl or hydroxypropyl when a food product is disposed to deter high moisture contents in the stools after eating (Stephen et al. 2006). The films can be manufactured from edible sodium carboxymethylcellulose polymer with high water vapour sorption capacities and with low water vapour barrier characteristics. Besides, these films have good mechanical properties like high strength and hard structure (Alyanak, 2004).

Metabolism

The metabolism of cellulose and its derivatives has been researched comprehensively as dietary fiber constituents. They are very non-creative and no fermentable in early work appraised the replies of rats to sustentation with xylan, pectin, cellulose and corn bran by investigating the excretion of gases supervening administration of the refined materials as dietary constituents (Fleming and Rodriguez, 1983). Sniff gases were beholded to specify the size of fermentation happening in the large intestine. Increment of fermentation in the colon was demonstrated by boosted gas excretion ratio. Researchers revealed that diets which involve cellulose and corn bran usually led to gas excretion degree which was not importantly varied from the fiber-free controls. This situation indicates no fermentability near to cellulose. Some researchers have investigated the effect of fibres on faecal excretion of ignescent fatty acids (VFA) (Fleming and Rodriguez, 1983; Fleming and Gill, 1997). It was confirmed that the concentration of VFA in secreted feces for cellulose-containing diets is lesser than for the control diet. Higher levels of VFAs or SCFAs (short-chain fatty acids) in the colon are related to healthy profits and MCFAs (medium-chain fatty acids) that are absorbed by the colon more in a breeze might be auxiliary when small bowel function is damaged. Moreover, the chemical derivatives of cellulose are transpired to be safe for usage in foods. Such as cellulose they are indigestible, too. Neither remarkable radioactivity gathers in the organs of rats which were fed with MC, HPMC, HPC and CMC. Animals with acute or sub chronic toxicity fed to test in several percent of the diet and it was registered. A useful effect of soluble cellulosics with water in the diet is their very influential water retention, elevating large and voluminous stools (Jorgensen et al. 2001; Jorgensen et al. 2002).

Emerging technologies: Barrier films

As hydrocolloids like cellulose and its derivatives, pectin, starch and their derivatives are hydrophilic, the coatings which are manufactured from them have nature restricted moisture barrier characteristics. Nevertheless, provided that they are utilised in a gel formation, they can delay damp losses during short keeping time when the gel deals as sacrificing agent rather than a barrier to humidity conduction. Furthermore, because an adverse relationship between water vapor and oxygen permeability in some cases has been sighted, this type films can supply efficient conservation against the oxidation of lipid and other sensitive food matter. The hydrocolloid edible films are categorised into two groups by taking into account the nature of their constituents: proteins, polysaccharides or alginates. Hydrocolloidal materials such as proteins and polysaccharides used comprehensively for the designing of edible films and coatings have been widely investigated for preservation of fruits and vegetables lately (Ink and Hurt, 1987). There is a growing community attention for improvement of edible natural biodegradable coatings and it is thought that they substitute commercial synthetic waxes nowadays. In respect to this, it contains a polysaccharide-based progress of bivium food with carboxymethyl cellulose layer coating (Magdy et al. 2014). It can manufacture edible materials with film formalization capability, yet the functions and implementations of films and coatings upgrade potential evaluations. It can lessen covering formulations of selected gas transfer proportions; therefore, it can be outstanding tools to enlarge the shelf life of foods (Aruna et al. 2012).

Carboxymethyl cellulose, methyl cellulose and hydroxyl propyl cellulose will be manufactured which are beneficial for fabrication film. In of them, hydroxyl propyl cellulose polymers that are a thermo plastic resin, is shaped in thawed level and is benefitted in fabricating film. The covers which are obtained with cellulose derivations are comparatively durable to water penetration and they‘re not affected by fats, oils and non-polar organic solvents. The packing papers that are manufactured from methylcellulose acid palmitic are used in coating ice cream wafers. Cellulose covers hamper access of oil approximately 50% - 90% and there are profits of cellulose derivatives as film substrates for complex systems with respect to water vapor conduction control by decreasing oil ecliptic. These films are notably formulated for frozen foods to hinder removal of water from zones of high relative dampness to zones of low relative humidity and to conserve the textural features related to fresh prepared products. With this technique, HPMC is the first produced film.

This is encrusted by a sprayed coating machine with a thin layer of beeswax. Once these movies are performed 2-5 mm, it is sealed as produced material which is an outstanding water vapour barriers at a temperature lower the melting point of the wax and fat heat. Nevertheless, one of the authentic properties of these films is that hydrated HPMC film gels hinder humidity moves at temperatures above 65ºC. This situation declines transport from areas of relatively high water activity to areas of low water activity. In cake mixes formulated for microwave baking, developed eating, covering with antioxidative activity and the plusage of carboxymethyl cellulose to the formulation was determined to markedly advance its influences. Indeed, it has been raised redness in control samples of potatoes with 106.6% range the parts which eaten (Koh, 2013). Corn starch and carboxymethyl cellulose are sighted that they have a positive impact on quality parameters of cucumber by slowing their weight loss, pH, firmness, total soluble solid, microbial accrual and ascorbic acid retention (Portal et al. 2013). Since 1900 cellulose derivatives are materials that have been used in food wrap industry as novel bio-based alternatives and particularly their preparation methods are acquiring new attentions to dissolve cellulose efficaciously. The existence of raw materials, natural features of the film and coating styles of manufactured materials are some of advantages cellulose. Derivatives have abilities to consolidate mechanically and to advance the oxygen barrier characteristics of polymer materials (Paunonen, 2013).

To progress the delivery properties of edible polymer, the improvement of new technologies was a great topic for future studies. Currently, a lot the studies have been performed on the food practices on a laboratory scale. But it ought to focus upward of investigation on a commercial scale so as to supply more certain information that are illuminate about shopping of products covered with edible polymers. Food industries are searching edible polymers which can be used on a extensive spectrum and they desire not only to add worth to their products but also to develop their shelf life (Subhas, 2014).

Conclusion

Wood is one of main sources of cellulose, which is existing in foodstuffs of plant source of dietary fibres. Comparatively they are processed or exposed to chemical modification so as to supply additives for usage in the food industry. Powdered a cellulose and MCCs develop viscosity and ensure volume in the baking, dairy, frozen dessert and meat industries particularly once fat reduction is needed. The edible films treated coating formulations can diminish gas transfer ratios and they can be significant tools to progress shelf life of foods in the range of allowed ethers which provide the useful rheological properties.

As a consequence, cellulose and its derivatives are accepted widely. Those products have wide regulatory approval from organizations such as FDA, USP and EEC.

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