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Research Article

Wood Modification by Fluorocarbons of different chain lengths

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Abstract

Wood has useful characteristics due to which it has many uses and applications in particular in engineering and over all in every spheres of human life. But wood has also a lot of draw backs that limits its applications in many areas. One of the main is that wood is hygroscopic and has great tendency to absorb water and moisture due to major hydrophilic components of wood. The main aim of our research work is to modify the hydrophilic nature of yellow pine wood by blocking or decreasing (OH) groups inside the wood by using fluorocarbons of different chain lengths (CF_4, CF_6 ,CF_8.). These are very promising materials frequently used in textile sector to impart hydrophobicity in fibers. Main focus is by using different fluorocarbons to explore the potential of different chain lengths for wood modification by improving its hydrophobicity, thermal properties, fireret ardency, color protection and dimensional stability. In practice, different fluorocarbons were vacuum impregnated into the pine wood to reduce the density of (OH) groups in its molecular structure. Subsequently, the treated wood samples were characterized by Scanning electron microscope (SEM) for its surface morphology and surface activation and contact angle measurements were used to reveal the degree of super hydrophobicity of fluorocarbon modified wood. Water related properties like water and moisture sorption and ant swelling efficiency and fire resistance properties were also extensively tested. Finally test properties were optimized and correlations were established among the treatments parameters and improvements achieved by using fluorocarbons of different chain lengths. Since, fluorocarbon based chemical wood modification is low cost, innovative approach to suppress the shortcoming of normal wood in a non-toxic manner and has huge potential to find applications in furniture and construction sectors in near future.

Keywords: *Hydrophilic nature, fluorocarbons, Scanning electron microscope, super hydrophobicity*

1. Introduction

Wood is a natural material that is sustainable and renewable generally used for building and construction because of its precise strength, environmental and aesthetic appeal easiness. However, when wood is showing to the outdoors, a diversity of weathering factors, such as water, UV radiation and tremendous temperatures are identified to have a weakening effect on wood consequential varies in its plane uniqueness such as loss of gloss, discoloration, roughening, and extensive loss with even checking of mechanical properties. Water acting an important function in weathering deterioration of wood by accelerating degradation of cell wall components and washing absent the degradation products, ensuing in surface erosion (Sydin, I 2010).

In the majority cases, wood must have suitable protection to stay away from weathering induced deterioration by its outdoor service (Wang, X2014)

As we have already discussed that wood is organic substance and it consist of three fundamental parts calledhemi-cellulose, cellulose and lignin which contain carbon C, oxygen O ,hydrogen H, and also contain unsaturated fats, waxes, tripnoids, sap, pectin, proteins. Cellulose in the wood manage the hardness, elasticity and unyielding characteristics, while hemi-cellulose confined the cellulose constituents and lignin is used to create wood strong, elastic and thick to save it from bacterium who demolish the wood entirely. Here we discussed the major constituents of wood which plays a significant character in the structure and work of different arts (Sun, Y 2010).

The worth of (CO_2) is reducing by the wood plants due to which the variation in climates are measured down. Timber uses miniature amount of energy throughout its enlargement process, therefore they are not a great deal influence on the background as other property during their life cycles. When we look like the wood with other stuff like the wall of tangible then it acts as an elastic-material. The houses completed by wood are much better to the bricks houses because

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wood houses have no require for extraordinary finishes. To keep from humidity contents and fungus attacks wood is chemically treated yet it is soft-wood or hard-wood (Sun, Q. F 2012)

In this examination job, the dimensional and humidity elite of wood efficiencies after acetylation, butyrylation, and hexanoylation were evaluated. A notable antiswelling skill of modified timber kinds was obtained after three acylation medicines. In contrast to untreated wood in a comparable RH, all the symmetry dampness filling of acylated yellow pine timber at three relationships stickiness was significantly reduced. The MEE's decreasing request for adjusted yellow pine wood was hexanoylation with the indistinguishable rate of replacement hydroxyl collections. This shows that the atomic volume of the replaced acryl bunch also has an effect on the MEE of adapted wood, adding up to the trade rate of the hydroxyl collections (Chang, H. T 2002).

The competition of good quality woodbased substances with other materials increasing at the same time. An important aim of wood industry is to made low maintenance production. Building elements is a best example of low maintenance cost with their better function for long time On the other hand wood that grown naturally has better properties; its water susceptibility and biodegradability restrict its uses in better performance materials. Many researchers in 1930s have been made new technology to enhance wood properties.In European countries the uses of wood increasing continuously as a material in building industry. Wood's high durability needed during application, but native European wood species having not this high durability properties so this type of wood requires more protection to offer more durability. In outdoor situations to prevent microbiological degradation wood treated with biocides. The use of biocides less attractive from a commercial perspective due to environmentally motivated legislation and promotes to find out less cost modification technologies(Lu, S 2010).

A large number of particularly hardwoods, wood species, include a very low down permeability causes different problems throughout timber process. This issue consists of big, big materials, drying times, injured after drying, and exclusive procedures of drying. It is very hard to impregnate low-permeability wood timber with resins and preservatives. Additionally, extension stresses in yellow pine wood and cell lead to fresh artifacts and far above ground losses in sawn timber regeneration. Low permeability timber effects in the pulp and paper sector result in shallow chemical penetration into timber, requiring the use of smaller chips, greater chemical practices, and very high energy consumption. Over the previous 10 years at the University of Melbourne, increased permeability through microwave (MW) timber alteration (Vinden*et al.,* 20031) has been under examination. Significant technological developments at the University of Melbourne have resulted in three industrial apps living available for marketing(Torgovnikov, G 2009) .

Wood is firm ,absorbent and rubbery like structural tissue which contains (lignin, cellulose and hemi-cellulose) come together with some of minor constituents like proteins, fatty acids, resins, terpenoids and some inorganic nearby in the stems, branches and roots of plants and further timbered trees. It is essential and basic materials and parts among the other materials like plastics, metals, glass and plastics etc. The best resource of wood is trees.When specific indiscretion takes place in the regular growth of trees then it creates the bunch which affects the atomic structure of the wood. The bunch's geometric arrangement has tremendously innovative view. Wood contain cell structure therefore it consists heterogeneous and hygroscopic properties. These cells consist 15% to 25% hemi-cellulose and 40% to, half cellulose and correlated to a single species called tracheid and these type of wood commonly describes the geometric structure. Hardwood has extra clear complex structure than the soft wood (Mahr, M. S 2012).

Wood is not merely used for fire and building purposes but also commonly used in profitable purposes in all over the world from foundation of the mankind and forest play precise role to produce the commercial wood. This commercial wood acting a central character for the creation of bridges on the canals and mountains and also used to construct floors of ships and houses. Mostly wood is fashioned in the European countries like Germany, Russia, Australia, Netherland and Finland France. America used wood as a petroleum and lumber from thousands of years and lumber is the wood which is used for manufacture purposes (Hill, C. A. S 2013).

The area of earth consists of 31% natural forests and 4 billion has on semi-natural globally forests and highest amount of wood produce in Africa and Europe and these both countries are the extreme producer of the timber in all over the world. Wood contain reliable properties therefore it plays specific role in the lives of a human. But due to increasing in population the need of forests is increasing. Last few years due to increasing population human cuts the trees to build their houses and factories therefore a big loss of forests is produce. Forests are necessary to achieve the 300 thousands ha in every year because this quantity fulfills the need of a human (Warensjo, M 2014).

The system of performance attractive wood modification in which the response of small element to a hydroxyl group. The bulking percentage of the wood cells by the active different fluorocarbon chemicals brings the wood reverse approximately to its sea green volume so additional moisture can swell positive the wood to the expandable boundary of wood cell walls. Though, as all active different chemicals use so far are superior to the water particle and a number of swelling for all time takes place. The hydrophylicity of yellow pine wood is also varied throughout the yellow pine wood modification. Because of various chemical modifications, the moisture content is decreased, biological resistance increases. It revealed that the confrontation white –rot to russet decompose fungi as of numerous kinds of different chemicals of yellow pine modification. With the similar time the manage yellow pine wood samples revealed over almost 8% mass failure owing to white-rot fungi, 61% thrashing owing to brown rot assault and every one of the wood alternation chemistries found that the fungal hit had decreased. Propylene oxide was not as helpful as butylenes oxide due to effects observed in the dryness exams(Rowell, R. M. 2006).

There are four important factors which play important role in the growth of the fungi to decompose the wood and these four factors are water, suitable-temperature, oxygen and the food source which is timber. In these factors the most dangerous factor is the water (level of moisture in the timber). When fungi are attacks on any wood species then small spores are produce by it. These spores are very small and light-weight and carry with the air at long distances. When these spores fall on the wood species and if spores have better requirements for growth as 28% to 30% moisture then it germinates and decomposes the wood but if the moisture-contents are less than 20% the wood decay is not possible (Ermeydan, M. A 2014).

The aim of this work is to clearly investigate the possibility of fluorocarbons for wood modification. A number of properties namely, thermal and fire properties, water and moisture sorption, mechanical, dimension stability and leach resistance properties of the fluorocarbon treated wood will be extensively studied to optimized the improvements by using fluorocarbons of different chain lengths.

2. Results and discussion

This research was completed to modify the wood in the material science lab of Agriculture University Faisalabad Paris campus. During this research a number of different properties of yellow pine wood were identified in which bulking effect, weight percentage gain property, moisture gain, and water uptake, degree of hydrophobicity, thermal properties and fire properties. By using the resulted value different graphs were plotted to show the different modifying properties. These properties which were modified in this research work were given as

3. Coloration of the wood samples

Wood samples of wood were equipped by using the different chemicals. These different samples were treated by using the impregnated technique. By this method of modification just not only external part but also internal part of the wood was modified and the color of different wood samples was varied from ordinary color to dark brown as the different samples given below are untreated and treated samples. When different chemical methods apply on different wood samples the coloration varies which are fashioned in the yellow pine wood samples which given below in the figs.

Fig.1 Treated wood samples

4. Surface morphology of the treated wood samples

Surface morphology of treated yellow pine wood samples with different fluorocarbons was calculated by SEM in longitudinal direction and its result is display in fig 4.3 which is given below. It can be that seen in the SEM image that Crystals are obviously envisioning by the channels at hand in the samples of the yellow pine wood. When the sample of the yellow pine wood was treated with the different chemical of fluorocarbons then this chemical was deposited in the sample of yellow pine wood through its channels. A few quantity of the fluorocarbons was obtain into the cell wall of the different samples though the pore of the cell wall but the majority of the chemical was penetrated into the sample. When this chemical was entered in the different samples and when these samples were cure for commencement then their properties were varied, they become fire retardant ,hydrophobic and due to strong bonding between different wood samples and fluorocarbon their automatic strength was increased and their color was also altered

5. Weight percentage gain of wood samples

When different samples of wood are chemically modify then the modification of different wood samples means that new chemical bonds are fashioned to increase the properties of yellow wood samples and then it is essential to examine the cell wall of the yellow wood samples identify about the properties of different wood samples. Assessment of cell wall is means to define the dimension stability and the weight of yellow wood samples before and after the impregnation process with the different chemical solution of fluorocarbons and if the samples of wood after impregnation process and curing increase in its weight then its means that samples absorb a little chemical solution and its properties varied and gain in weight is called weight percentage gain (WPG). With this solvent swap over treatment cell Lumina was produced in the samples of wood due to their bulking effect increased and their swelling effect was decreased. The difference comparisons of weight percentage gain is shown by the clarification of graphical representation which is given as:

Table 1 (WPG) verses concentration of the solution (CF_8)

Percentage concentration of the solution (%)	Weight percentage gain of the wood samples (%)
0.5	0.145
1	0.146
2	0.148
4	0.149

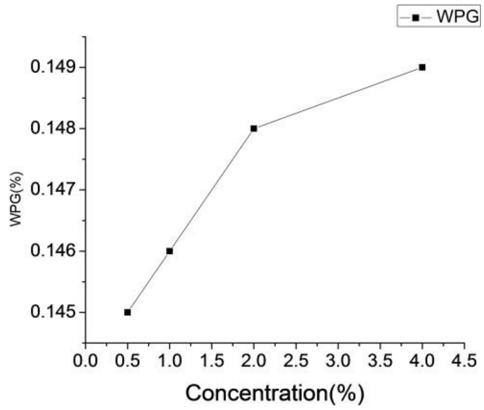

Fig.2(WPG) verses concentration (CF_8)

Table 2(WPG) verses concentration of the solution (CF_6)

Percentage concentration of the solution (%)	Weight percentage gain of the wood samples (%)
0.5	0.147
1	0.148
2	0.150
4	0.155

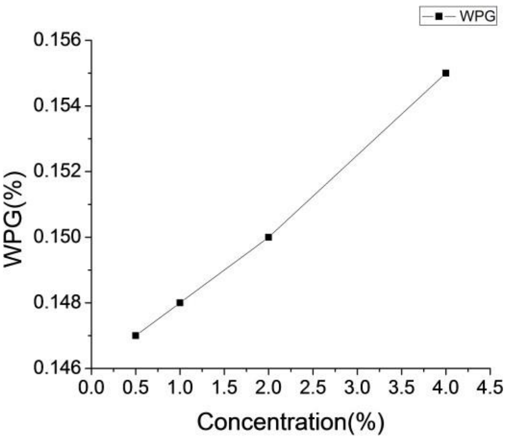

Fig.3(WPG) verses concentration

Table 3(WPG) verses concentration of the solution (CF_4)

Percentage concentration of the solution (%)	Weight percentage gain of the wood samples (%)
0.5	0.148
1	0.149
2	0.153
4	0.158

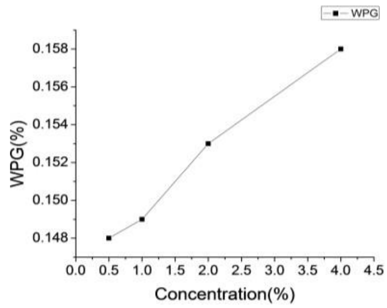

Fig.4(WPG) verses concentration (CF_4)

Three different concentration of different fluorocarbon solution by using different chain lengths were taken and the prepared wood samples of yellow pine wood were impregnated by these concentrations and after that their weight percentage gain was calculated. The (WPG) values verses concentrations of solution values which were calculated are shown in the 4.1 table and graph of using these values shown above which shows that as the concentration of the fluorocarbon solution (CF8) increase the (WPG) values are gradually increase.

6. Bulking effect of the wood samples

Bulking effect of the wood samples is mean to change in the volume of the treated sample as compared to the volume of the untreated sample. When a sample is dip into the chemical solution then it absorb chemical solution and when it is cured the its weight increases as compare to its initial weight due to this its cell wall swells and its volume increases but it is not long-lasting changing which are produce in the cell wall of the wood samples. The changes which were produced due to this treatment are shown in the table and the graph which are both given below.

Table 4 Concentration of the solution verses bulking effect of the samples (CF_8)

Percentage of the solution (%)	Bulking effect (%)
0.5	0.98
1	2.14
2	3.39
4	4.88

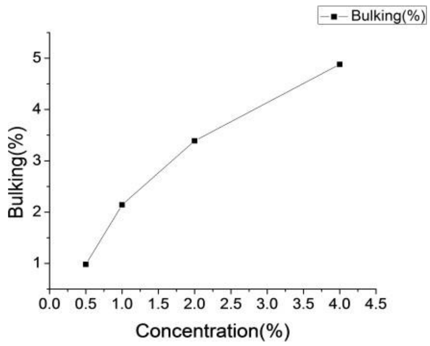

Fig.5 Concentration of the solution verses bulking effect (CF_8)

Table 5 Concentration of the solution verses bulking effect of the samples (CF_6)

Percentage of the solution (%)	Bulking effect (%)
0.5	0.90
1	1.98
2	3.3
4	4.38

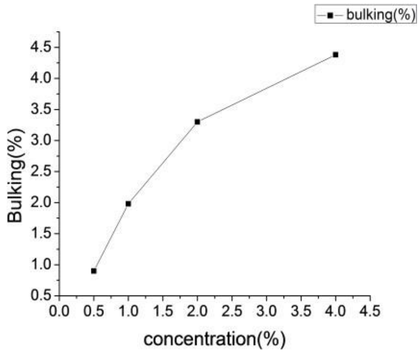

Fig.6 Concentration of the solution verses bulking effect (CF_6)

Table 6 Concentration of the solution verses bulking effect of the samples (CF_4)

Percentage of the solution (%)	Bulking effect (%)
0.5	0.82
1	1,9
2	3.2
4	4.28

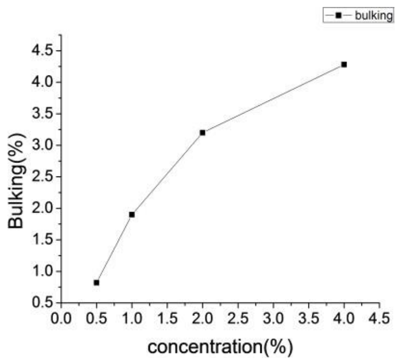

Fig.6 Concentration of the solution verses bulking effect (CF_4)

The values of bulking effect were calculated by using the three different concentrations of the chemical solution by using different fluorocarbons. The values of bulking effect verses concentrations of the solution are shown in the above table and concentrations bulking values increases.

7. Water gain property of wood samples

In water gain property untreated and treated samples with fluorocarbon were placed into the water for 47 hours and taken their values in different hours. It was shown that the untreated samples were absorbed more water than the treated samples, its mean repulsive property was developed in the treated samples due to fluorocarbon. It's mean with the increase in WPG water uptake decreases. As shown in the table below

Table 7 Water uptake of treated and untreated samples verses time (CF_8)

Time (Hours)	Untreated samples	0.5% Concentra tion	1% Concentra tion	2% Concentr ation
1	10.21	7.1	6.69	6.68
2	10.52	7.3	7.0	6.9
3	10.72	8.0	7.2	7.0
13	11.42	9.10	8.91	8.77
23	11.90	9.50	9.28	9.19
47	12.06	11.0	10.5	9.95

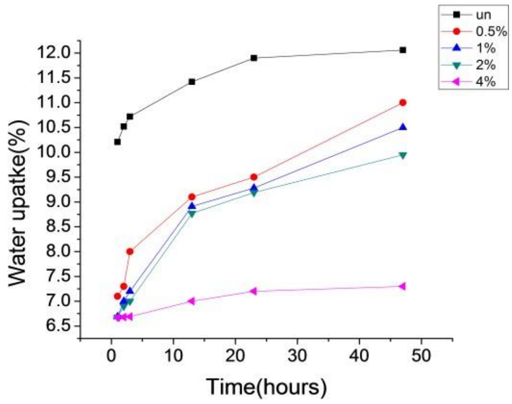

Fig.7 Water uptake of treated and untreated samples verses time (CF_8)

Table 8 Water uptake of treated and untreated samples verses time (CF_6)

Time (Hours)	Untreated samples	0.5% Concentr ation	1% Concentra tion	2% Concentra tion
1	10.16	8.1	7.69	7.68
2	10.29	8.3	8	7.9
3	10.38	9.0	8.2	8.0
13	11.10	10.10	9.91	9.77
23	11.60	10.25	10.28	10.19
47	13	10.5	10.78	10.95

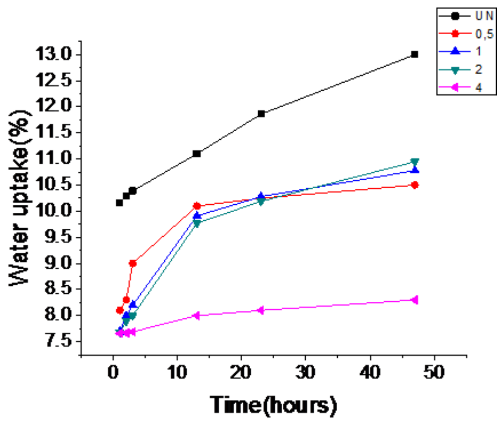

Fig.8 Water uptake of treated and untreated samples verses time (CF_6)

Table 9 Water uptake of treated and untreated samples verses time (CF_4)

Time (Hours)	Untreated samples	0.5% Concen tration	1% Concentra tion	2% Concentr ation
1	10.9	9.1	8.68	8.66
2	10.26	9.3	9.01	8.9
3	10.32	10	9.23	9.0
13	11.10	11.10	10.90	10.77
23	11.36	11.50	11.39	11.19
47	14.5	12.15	12.9	11.96

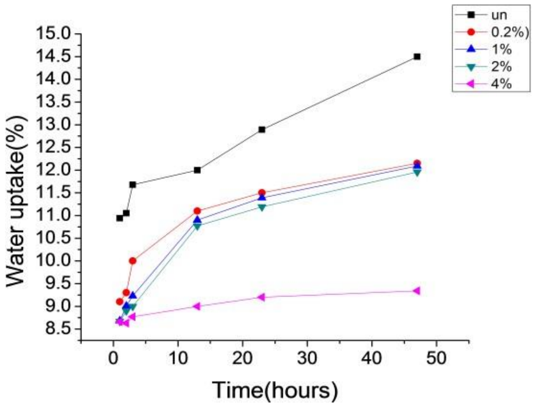

Fig.9 Water uptake of treated and untreated samples verses time (CF_4)

Treated samples having three different concentrations by using different chemical solutions and it was shown that with increase in concentration water gain decrease and untreated samples absorb more water than treated samples in 1, 2, 3, 13, 23 and 47 hours. To express the values of the water gain graph of finding values is given above.

8. Antiswelling efficiency of wood samples by using different chain lengths

When the different samples of yellow pine wood were treated with different fluorocarbons then the cell-wall of the different samples swells up and the values of (AES) were taken by the difference in the dimensions of the untreated and the treated wood samples. The taken values of the dimensions are related to the rise and the external-volume of cell-wall of the wood samples. We can get accurate results of CF_8 without measuring values.

Table 10 ASE verses concentration of the solution (CF_8)

Concentration of solution(%)	Weight percentage gain (%)	Anti-swelling efficiency (%)
0.5	0.145	39
1	0.146	42
2	0.148	47
4	0.149	53
7	0.159	58

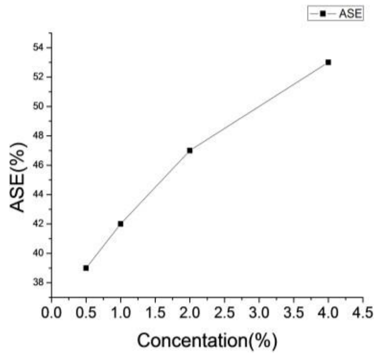

Fig.10 ASE verses concentration (CF_8)

Table 11ASE verses concentration of the solution (CF_6)

Concentration of solution (%)	Weight percentage gain (%)	Anti-swelling efficiency (%)
0.5	0.147	35
1	0.148	38
2	0.150	43
4	0.155	48
7	0.159	52

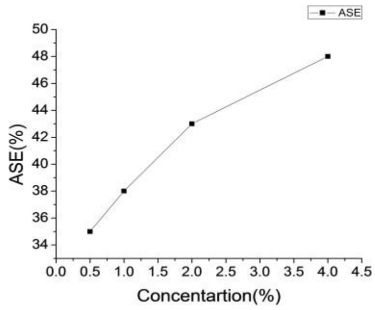

Fig.11ASE verses concentration (CF_6)

Table 12 ASE verses concentration of the solution (CF_4)

Concentration of solution(%)	Weight percentage gain(%)	Anti-swelling efficiency (%)
0.5	0.148	32
1	0.149	36
2	0.153	39
4	0.158	41
7	0.163	45

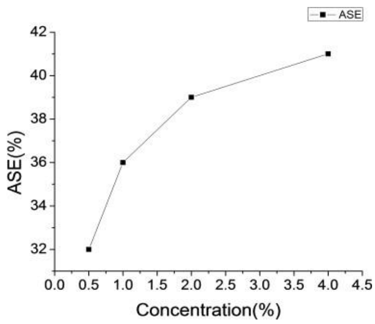

Fig.12ASE verses concentration (CF_4)

In the process of anti-swelling efficiency three different concentrations were taken and applied on the samples of yellow pine wood by using different fluorocarbons. Then the values of (ASE) were taken by comparing the (WPG) and it was shown that with the increase in (WPG) anti-swelling efficiency was also increased and we get better result of fluorocarbon (CF_8).

Conclusion

In the ancient times a large quantity of wood was washed out due to needless use, biological attacks and cuttings but behind that its significance was exposed because it was using in all spheres of life and particularly in engineering. To save the wood from little comings wood chemical modification move toward was applied. In chemical wood modification different nontoxic chemicals were applied by employ dissimilar approaches. In our work we used different fluorocarbons for modifying yellow pine wood surfaces. Fluorocarbons is frequently used in textile sector to transform the textile fiber commencing hydrophilic to super hydrophobic by using different techniques. The main purpose of this research work is to apply these different fluorocarbons for the modification of the yellow pine wood and to make it valuable and fire retardance.

In practice, different wood samples were initially dried at 110 °C in oven then solutions of different concentrations were prepared in distilled water and used these different solutions on the wood by vacuum impregnating process. Subsequently, these different wood samples were dried at room temperature for 5 to 6 days then again cured at 110 °C to get ready made products. Prepared wood samples were subjected to different testing related to water related properties. Surface morphology of the treated wood samples was studied by SEM. SEM images showed that the different solutions were well deposited into the inside of the wood uniformly. Results revealed that wood treated with bigger chain length showed more improved water related properties as compared to shorter chain length fluorocarbon treated wood. Since, fluorocarbon based chemical modification is cost effective, innovative, easy doing approach and has a huge potential to find different applications in furnishings and building sectors in near future

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