Novel D-glucose Based Glycomonomers
Synthesis and Characterization

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Abstract—In the last decade, carbohydrates have attracted great attention as renewable resources for the chemical industry. Carbohydrates are abundantly found in nature in the form of monomers, oligomers and polymers, or as components of biopolymers and other naturally occurring substances. As natural products, they play important roles in conferring certain physical, chemical, and biological properties to their carrier molecules. The synthesis of this particular carbohydrate glycomonomer is part of our work to obtain biodegradable polymers. Our current paper describes the synthesis and characterization of a novel carbohydrate glycomonomer starting from D-glucose, in several synthesis steps, that involve the protection/deprotection of the D-glucose ring via acetylation, tritylation, then selective deprotection of the aromatic protective group, in order to obtain 1,2,3,4-tetra-O-acetyl-6-O-allyl-β-D-glucopyranose. The glycomonomer was then obtained by the allylation in drastic conditions of 1,2,3,4-tetra-O-acetyl-6-O-allyl-β-D-glucopyranose with allylic alcohol in the presence of stannic chloride, in methylene chloride, at room temperature. The proposed structure of the glycomonomer, 2,3,4-tri-O-acetyl-1,6-di-O-allyl-β-D-glucopyranose, was confirmed by FTIR, NMR and HPLC-MS spectrometry. This glycomonomer will be further submitted to copolymerization with certain acrylic or methacrylic monomers in order to obtain competitive plastic materials for applications in the biomedical field.

Keywords—allylation, D-glucose, glycomonomer, trityl chloride

I. INTRODUCTION

In Glycopolymers are synthetic polymers with pendant saccharide moieties [2, 3]. It is well known that saccharides decorate the surfaces of all cells (glycocalyx) in the form of polysaccharides, glycoproteins, glycolipids, and other glycoconjugates [4]. The pendent sugar moieties play a significant role in a number of significant biological processes including inflammation, cell-cell contacts, signal transmission and fertilization [5].

Therefore, polymers with sugar moieties have been of interest due to their biomimetic properties and significance in biological applications [6].

The design and synthesis of polymer materials with ability of molecular recognition can be regarded as the finest exhibit of this biomimetic approach [7]. Stimuli-responsive polymers have received much attention in the last years, because they undergo abrupt physical or chemical change in response to change of environmental conditions such as pH, temperature, light, magnetic field, and glucose [8].

Different approaches to synthesize glycopolymers using conventional and controlled radical polymerization, living anionic polymerization, cyanoxyl mediated polymerization, ring opening polymerization and post-polymerization modification have been described. In these procedures glycomonomers with protected and unprotected carbohydrate groups have been utilized. That is dependent on the simplicity of saccharide stereospecific functionalization, the solubility of the monomer and polymer, the potential incompleteness of the protective group removal, and the purification easiness [9, 10].

In accordance with our continuing interest to obtain biodegradable polymers, in this study we report the results obtained in the synthesis and characterization of 2,3,4-tri-O-acetyl-1,6-di-O-allyl-β-D-glucopyranose. The infrared and NMR analyses confirmed the structure of the synthesized compound, and additionally their molecular weight was confirmed by HPLC-MS analysis. The synthesis of this derivative based on D-glucose (I) was achieved according to Scheme 1, and involves several steps of protection/deprotection of the D-glucose in the pyranose form.
MATERIALS AND METHODS

D-(+)-glucose, trityl chloride, pyridine, allyl alcohol, ethyl acetate, hexane, allyl chloride, DMF, sodium hydride, diethyl ether, diisobutylamine, and methanol were purchased from Merck. Sodium bicarbonate was purchased from ChimoPar, and sodium sulfate from Acros Organics. All this materials were used without further purification.

All syntheses were monitored using thin-layer chromatography (TLC) performed on silica gel plates, Merck, DC-Autofolien Kiesegel 60 F 254, using different eluants.

FT-IR Analysis. The FTIR spectra were recorded on a Jasco FT/IR-410 spectrometer. The IR analyses were done using KBr pellets.

NMR-Spectroscopy. The NMR spectra were recorded on a Bruker Avance DRX 400 spectrometer using CDCl₃ as reference.

HPLC-MS Analysis. Mass spectrometry experiments were performed using a quadrupole time-of-flight mass spectrometer, equipped with an electrospray ion source (Agilent 6520 Accurate Mass Q-ToF LC/MS). The samples were dissolved in a chloroform/methanol 6:4 (v/v) mixture. The solutions were introduced into the ESI source via a syringe pump at a flow-rate of 0.2 mL/min. The electrospray interface was set in positive ionization mode with the capillary voltage at 4000 V and a heat source of 325°C, in full scan spectra (m/z 100–1000). Nitrogen was used as a drying (7 L/min) and nebulizing gas (35 psi). Data were collected and processed using a MassHunter Workstation software.

RESULTS AND DISCUSSION

A. FT-IR Results

Table 1 presents the FTIR spectra of 2,3,4-tri-O-acetyl-1,6-di-O-allyl-β-D-glucopyranosyl (5). The signals assigned to the pyranose D-glucose ring, mainly the aliphatic C-H stretching, are placed between 2850 and 3000 cm⁻¹, also the acetic skeleton exhibits the esteric C=O bond at about 1750 cm⁻¹, while the C-O bond is traceable at about 1250 cm⁻¹. The double C=C bond from the allylic residue expresses asymmetric stretching at about 1300 cm⁻¹, while its bond stretching is placed in the spectrum at about 1650 cm⁻¹, proving that the given structure is accurate [13].
TABLE I
THE FTIR SPECTRA OF THE D-GLUCOSE DERIVATIVE

<table>
<thead>
<tr>
<th>Compound</th>
<th>Band frequency (cm⁻¹)</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,3,4-tri-O-acetyl-1,6-di-allyl-β-D-glucopyranose</td>
<td>3082.65; 1648.84</td>
<td>=CH₂ asymmetric stretching; C=C bond stretching</td>
</tr>
<tr>
<td></td>
<td>2955.38; 2926.45; 2854.13</td>
<td>aliphatic C=H stretching</td>
</tr>
<tr>
<td></td>
<td>1750.08; 1440.56; 1369.21; 1230.36</td>
<td>C-O stretching</td>
</tr>
<tr>
<td></td>
<td>768.49; 691.35; 601.68</td>
<td>out of plane γ vibrations for aliphatic C-H stretching</td>
</tr>
</tbody>
</table>

B. NMR-Spectroscopy

The NMR spectroscopy also confirmed the D-glucose derivatives structure. The 1H-NMR spectrum of 5 is shown in fig. 2. The spectrum shows the characteristic signals for the acetic CH₃ protons at about 2 ppm (parts per million), thus proving that this protective group has not been lost during the allylation in strong oxidative conditions. The protons from the sugar ring display signals between 4.4 and 5.0 ppm. The signals of the protons in the allylic group, involved into the double bond, are the most shifted to the left of the 1H-NMR spectrum, displaying signals between 5.4 and 5.6 ppm. The methylene attached to the double bond express signals around 4.5 ppm [14, 15].

The 13C-NMR spectrum of 5 is shown in CDCl₃ and confirms its structure as well. The acetate protective group expresses its signals at about 20 ppm for CH₃ and around 170 ppm for the C=O esteric bond. The signals characteristic to the C=C bond are placed from about 127 to about 132 ppm, whereas the CH₂ attached to the double bond expresses signals at about 60 and respectively 73 ppm, the one linked to the anemic O belonging to the D-glucose ring being more shifted to the right.

The signals assigned to the pyranosic D-glucose ring are placed between 62 and 70 ppm, the anemic C though is shifted much more to the left, to about 90 ppm.

C. HPLC-MS Analysis Additionally

The HPLC-MS analysis confirms the molecular weight of product 5. Fig. 3 displays the mass spectrum for compound 3. It shows that the most abundant ion corresponds to the [M+Na]⁺ single-charge sodium adduct at m/z = 373.65. The peak observed at m/z = 720.37 is associated with the presence of the [2*M+Na+H]⁺ adduct, corresponding to the dimmer of the molecule associated with Na⁺ and H⁺.
Fig. 4 shows the collected mass spectrum of 4, showing the molecular peak as an adduct with K$^+$ at $m/z = 439.02$ and as an adduct with Na$^+$ and H$^+$ at $m/z = 424.83$, thus reassuring the proposed structure for the new glycomonomer. The accompanying peak at $m/z = 373.21$ can be assigned to the single charged peak of the molecule which has lost one double bond from the two protective allylic groups.

V. CONCLUSION

One novel glycomonomer deriving from D-glucose was successfully synthesized and analyzed using FTIR and NMR (1H-NMR and 13C-NMR) spectroscopy and HPLC-MS. The FTIR and NMR spectroscopy results confirmed the structure of this compound. The HPLC-MS analysis confirmed the molecular weights of 5. The synthesis of this D-glucose derivative (in high yields, 86% for each step) is part of our work to obtain biodegradable polymers. Polymer materials derived from carbohydrates are potentially biodegradable and lead to minimum environmental pollution.

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