New annual Hungarian plants (industrial grasses) as raw materials in the pulp and paper industry

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Abstract

Important task is, considering sustainable development, the better utilisation of the yearly renewable biomass. Large proportion of the Great Hungarian Plain can not be utilised for food production as earlier, consequently it is open for cultivation of plants for industrial utilisation. In one of the Hungarian Agricultural Centres in Szarvas appropriate researchers have developed, patented and produced in large scale a new yearly renewable source of biomass called "Szarvas – I Industrial Grass". Details related to agricultural production of the studied industrial grasses has also been discussed. The yearly production (metric tons/hectare) of biomass of industrial grass origin has been compared with those of conventional agricultural (e.g. straw, hemp, flax) and forest (e.g. Coniferous trees, Broad-leaved trees) plants. In cooperation with the Szarvas Research Group the Hungarian Paper Research Institute and with the a Research Group at the Department of Organic Chemistry and Technology of the Budapest University of Technology and Economics have started research activities for utilising this grasses in the paper industry.

Complex analytical studies in separating different components of industrial grass proved the possibility of utilisation of its components as follows: extracted by hexane 1.5 %, hot water extraction 1.0%, holocellulose 65.0%, lignin 29%, ash content 1.0 %.

Keywords: industrial grass, renewable raw material, pulp- and paper industry

1. Introduction

Three Hungarian groups of researchers cooperate in the project: the first one is Greenline Hungary Ltd. located in Szarvas the second one is the Paper Research Institute at the West-Hungarian University (Sopron) and the third one is the Department of Organic Chemistry and Technology of the Budapest University of Technology and Economics.

Dr. János Janowszky in cooperation with his son Zsolt Janowszky (Greenline Hungary Ltd.) has improved within several decades the industrial grass as one of yearly renewable cellulosic raw material.

The possible application of industrial grass as raw material of pulp and paper industry has been the subject of research for decades earlier at the direction of Dr. Éva Polyánszky and since more than five years by Associate Professor István Lele (Paper Research Institute at the West-Hungarian University).

Different investigations and analyses in correlation with the elaborated technologies and products have been performed at the Department of Organic Chemistry and Technology (Budapest University of Technology and Economics).

2. Results and discussions

2.1. The industrial grass plant

Dr. Janowszky and his group have developed since the middle of the eighties types of grasses of high solid content adaptable for energetic and industrial uses.

Such plants have to be selected which were not too sensitive to the quality of the soil of their cultivation. In success it might increase the chance of employment for inhabitants of such areas.

There is plenty of land (700-800 thousand hectares) in the Hungarian Great Plain not suitable for food production which however might be used for cultivation of plants of industrial purposes *(Figure 1)*.

The discussed industrial grass, a perennial shrubby plant, has been hybridized from grasses of saliferous area of lowland and of Middle-Asian arid areas. Up to 1.8-2.5 m deep in to the soil can be found the great mass of its root system. Its 180-220 cm high flat and hard, slate green stem is foliaged sparsely. The numbers of nodes are on the stem 2-4. The leaves are stiff and their surface is uneven. Their 20-30 cm high yellow inflorescence is straight.
Flourishing ends at the beginning of July and the grains can be harvested generally at the beginning of August. The 0.8-1.2 cm long grains are of lance shaped. 6.0-6.5 g. is the mass of 10000 pieces of grains.

Figure 1: Industrial grass (number of nodus: 2-4)

2.2. Cultivation of industrial grass

The lifetime of industrial grass is long. It can be cultivated for up to 10-15 years at the same agricultural location. The cost of its plantation is by 90% less than that of the forests. It is yearly renewable for industrial application opposite to sources of wood origin which might be utilised once in 5-8 years.
Perennial grasses need only single preparation of the soil followed by only a few activities in plant protection. Their cultivation might prevent the soil erosion. It is an excellent biomeliorative plant (biological soil protection) *(Figure 2)*.
Up to 20-25 metric tons/hectare might be eroded under cultivation of one year plants whereas only less than 0.2-2 t/hectares under cultivation of perennial plants.
Industrial grass is resistant to vegetable-illnesses such as powdery mildew, brown-red rots.

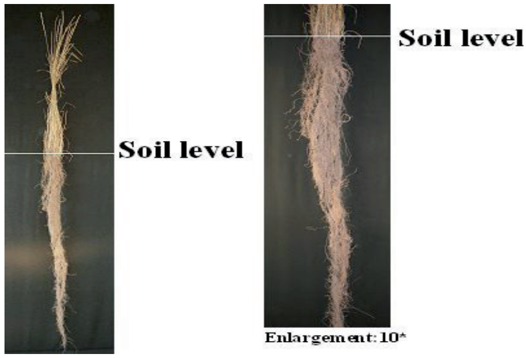

Figure 2: Industrial grass as biomeliorative plant

The yield of industrial grass reaches10-15 t/hectare in the first year after plantation, later, depending on the quality of the soil and on the yearly average participations, the yield might reach 10-25 t/hectare *(Figure 3)*.
No expensive and special machinery is needed for its growing and harvesting, because those of corn cultivation are easily adaptable.

Figure 3: Cultivation of industrial grass

The cultivation of industrial grass can be interrupted at any time not changing the quality of land use (plough land).

2.3 Significant characteristics of industrial grass

The Table 1 shows the comparison between significant characteristics of industrial grass with those of selected other plants. The ash content of industrial grass is 50 % of that of straw whereas it is the double of that of broad leaved trees.

Chemical composition	Coniferous trees	Broad-leaved trees	Cereal straw	Industrial grass
Extract content (n-hexane)	1.5	1.5	3.5	5.0
Hot water extract	1.0	3.0	16.0	15.0
Holocellulose	65.0	68.0	62.0	67.0
Lignin content	29.0	17.0	13.0	17.0
Ash content	1.0	2.0	8.0	3.5

Table 1: Chemical composition of traditional raw materials as well as that of industrial grass [%] [1]

The lignin content of industrial grass is approximately equal to that of broad leaved trees and about two third of that of coniferous trees.
The higher is the lignin content of a source the higher is their capacity of energy. This is due to the high carbon content (64%) of lignin.
The holocellulose content of the industrial grass is rather high (67%) comparable with those of the coniferous trees (65%) broad leaved trees (68%), consequently it is promising raw material for production of papers.

3. Fields of application
Industrial grass is able to substitute wood as industrial raw material in different fields of application.
The seed harvest of industrial grass is rather simple and economic. Local industrial raw material is being established by its cultivation enabling short and not expensive transportation.

Possibilities for making use of industrial grass:
– Source of energy (in solid, fluid and gaseous state),
– Raw material for pulp and paper industry,
– Fibrous raw material for different other industrial purposes,.
– Use in the chemical industry,
– Use in building industry,
– Animal feed,
– Biological soil conservation, soil reclamation.

3.1. Source of energy
From the second crop right after harvesting animal food might be produced (e. g. hay) or it might serve for the production of biogas [2].
The yearly productions of biomass/hectare of industrial grass compared with that of different plants are shown in *Table 2* [3], [4].

Raw material	Biomass suitable for industrial utilisation [t/year/hectare]
Coniferous	1.5 – 2.0
Broad-leaved trees	2.5 – 3.0
Grain straw	3.5 – 4.0
Flax	2.5 – 3.0
Hemp	6.0 – 8.0
Industrial grass	10.0 – 15.0

Table 2: Produced different biomass by one hectare of different plants [t/year]

The relative yearly production of biomass by industrial grass is twice up to ten times of that by other plants *(Figure 4).*

Figure 4: Energy content of industrial grass

3.2. Raw material for pulp- and paper industry
Bleached (elemental chlorine free (ECF)) and unbleached cellulose has been produced from industrial grass within alkaline conditions in the presence of anthraquinone under industrial and pilot scales *(Figure 5)* [5].
Packaging paper has been produced from the unbleached raw material (*Table 3*) whereas writing-printing one from the bleached resources (*Table 4, 5*). The properties of 44 % containing industrial grass based writing-printing paper have been evaluated under comparison with that of regular control paper (detailed data in *Table 4*).

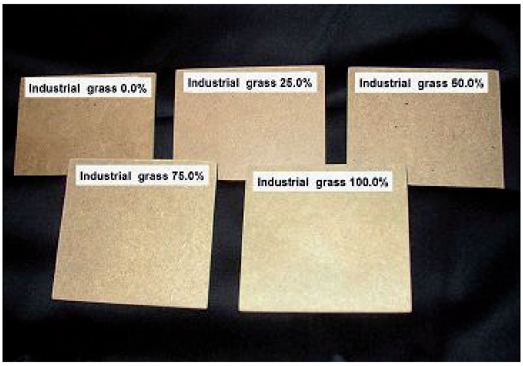

Figure 5: Industrial grass as raw material for pulp- and paper industry

Constituents	Control paper	Industrial cellulose containing paper
Fibres [%]		
Sulphate pine (Arhangelszki)	36	36
Sulphite pine (SÖDRA-BLUE)	20	20
Eucaliptus	44	0
Industrial grass pulp	0	44
Auxilary materials [%]		
Filler (PCC)	20	20
Size material (ASA)	0.3	0.3
Starch in masse	0.8	0.8

Table 4: Composition of writing-printing experimental and control samples

Properties	100 % OCC*	1/3 industrial grass + 2/3 OCC	2/3 industrial grass + 1/3 OCC	100 % industrial grass
Tensile index [Nm/g]				
md**	63.1	66.4	68.6	76.9
cd***	31.3	33.1	29.6	43.2
Elongation [%]				
md	1.48	1.61	1.65	1.83
cd	3.45	4.18	4.63	5.19
Burst index [kPam²/g]	2.39	2.61	2.91	3.23
Tear index [mNm²/g]				
md	7.09	7.21	7.37	7.69
cd	7.37	7.7	8.23	8.73
SCT [kN/m]				
md	1.75	2.66	3.06	3.27
cd	1.13	1.76	1.98	2.27
CMT_{30} [N]	108.0	127.4	142.2	163.1
RCT [N]				
md	60.7	87.4	94.6	110.3
cd	79.5	106.8	112.9	132.7

*OCC: Old Corrugated Containers
**md: machine direction
***cd: cross direction

Table 3: Properties of packaging paper produced from industrial grass cellulose, under industrial conditions

Properties	Control paper	Industrial cellulose containing paper
Grammage [g/m²]	80.3	79.5
Thickness [mm]	0.136	0.132
Gravity [g/cm³]	0.59	0.602
Tensile index [Nm/g]		
md*	64.6	66.1
cd**	21.4	26.0
Breaking length [m]		
md	6.581	6.740
cd	2.185	2.652
Elongation [%]		
md	1.0	1.1
cd	3.4	3.2
Tearing resistance [mN]		
md	544	523
cd	716	624
Tear index [mNm²/g]		
md	6.3	5.7
cd	7.8	7.2
Burst pressure [kPa]	152.5	159.7
Burst index [kPam²/g]	1.9	2.0
Brighteness [%]	82.4	85.2
Opacity [%]	93.1	91.3
Ash content (525°C) [%]	17.8	15.2

*md: machine direction
**cd: cross direction

Table 5: Properties of writing-printing papers

It could be concluded that no significant differences occurred between characteristics of indusrial grass containing and control papers.

Summary
Evaluating our experiments performed so far the industrial grass proved to be a hopeful yearly renewable raw material for energetic as well as for industrial application. It can be concluded from results of pilot and industrial scale production that the industrial grass cellulose was equivalent or even better in quality and value with papers produced from traditional resources.

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FT-IR and UV/VIS analysis of classic and recycled papers

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Abstract
The properties of classic and recycled papers with and without surface coatings were investigated by several methods. With the infrared attenuated total reflection spectroscopy, the molecular structure on sample surfaces was identified and analysed. This way the filler and coating pigment were detected and their amount on classic and on recycled papers. Ultraviolet/visible spectroscopy enables the reflectance and transmittance measurements. The most important result was detection of the optical brighteners and comparison of its amount in our paper samples. These results were compared with the calcium carbonate and china clay content in the bulk of examined papers, as calculated from the ash contents. Furthermore, differences between classic and recycled materials are discussed in more details.
Keywords: Recycled paper, FT-IR spectroscopy, UV/VIS spectroscopy, ash content.

1. Introduction

The infrared (IR) absorption spectroscopy is frequently used to identify the molecular structure of a sample qualitatively and quantitatively. The most useful for the analysis is the mid-IR spectra, i.e. the region from 4,000 to 400 cm^{-1}; in the upper wavenumber part (up to 1300 cm^{-1}) vibrations of functional groups in molecules can be detected, whereas the region with lower wavenumbers represent the so-called molecular fingerprint region of the analyte [1, 2]. The IR absorption is analysed with the help of absorbance spectra by the position, intensity (height), half-width and the shape of individual peaks.

The peak position is the basic characteristic of the corresponding vibration. It reveals an effective mass of vibrating group of atoms, the vibration geometry and coupling with the immediate surroundings, i.e. the vibrational species in the neighbourhood. A different position can indicate different effective mass of vibrating group and/or their different surroundings. The first effect produce different characteristic peaks, whereas differences the potential field in the surrounding of vibrating species can, in