WOOD LIQUEFACTION – AN ALTERNATIVE WAY FOR END-OF-LIFE TRANSFORMATION OF WOOD WASTE

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Wood wastes

- Various wood products have become more frequently re-used, recycled, and discovered as raw materials for platform molecules.
- Recycled wood products are in most cases made from post-consumer and post-industrial resources.
- Wood wastes must be cleaned and processed to remove any contaminants and to reduce the particle size.
- After these processes, this material may be used to manufacture a range of high quality products for different markets.

Wood liquefaction

- There are numerous possibilities of liquefied wood application (production of polyurethane foams and coatings, preparation of activated carbon fibres, as a fuel and as a urea- and melamine ureaformaldehyde resin substitute or modifier).
- In the wood-based materials technology the most important is to develop an alternative binder, based on natural compounds, which would replace the commonly used amino-resins.
- The ability to produce bio-adhesives based on liquefied wood and to apply them in wood-based panels production can significantly increase the use and exploitation of lignocellulosic biomass.

Goal

- to evaluate the possible transformation of various wood waste by means of liquefaction
- to investigate chemical composition of both liquefied wood and liquefaction residues
- to investigate the potential application of rapid techniques such as NIR and XRF for screening chemical properties of various bio-resources

Utilization of wood waste products, including liquefied wood biomass and post-consumer wood with the prospect of their use in the technology of composite wood products

Experimantal samples

4 types of wood waste:

- bark
- mixed hardwood/softwood powder,
- pine sawdust from wood processing industry
- beech sawdust from wood processing industry


bark


wood powder


pine sawdust

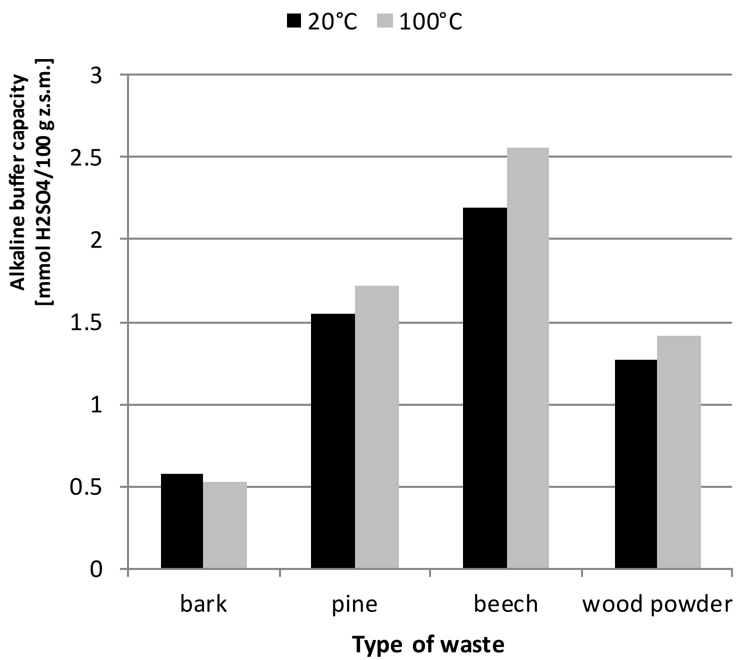

beech sawdust

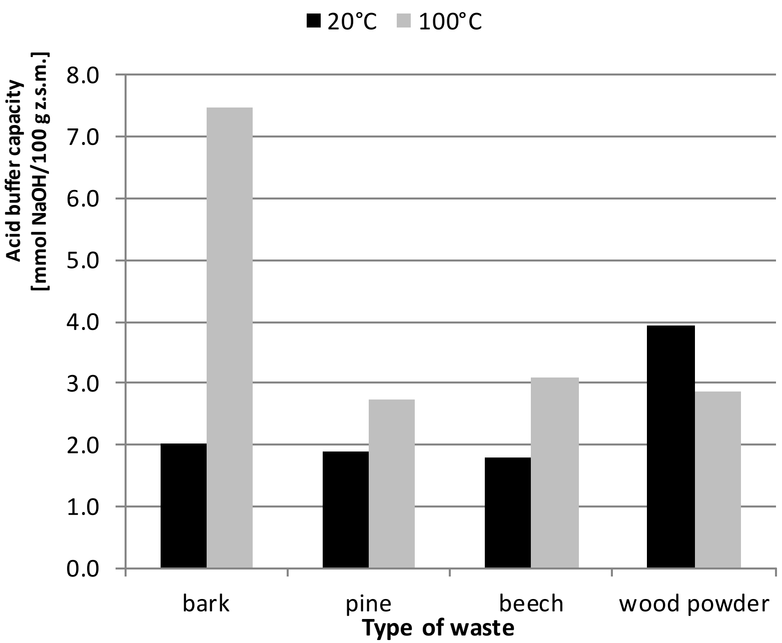
Particle fractions ≤0,5 mm to ≥0.25 mm were used for the liquefaction process.
Prior to liquefaction particles were dried at 103°C for 24 hours.

Raw materials characterization

Tested property	Measurement unit	Type of raw material			
		bark	pine sawdust	beech sawdust	wood powder
Bulk density	kg/m^3	218	57	62	96
Formaldehyde content	mg/100 g total dry mass	0.3	0.7	0.3	0.7
pH, tested in 20°C	-	3.7	4.3	4.7	4.3

Buffer capacity





Buffer capacity have important influence on the mechanical properties, as well as formaldehyde content, in case of future use of the liquefied wood as additive in the panels production. Drop of mechanical properties and increase of formaldehyde content is observed with growth of acid buffer capacity [Frąckowiak 2005].

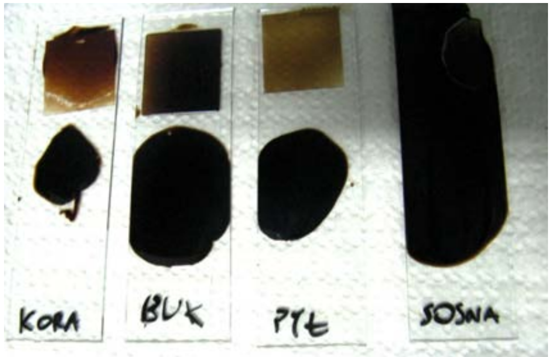
Liquefaction

The liquefaction reaction was carried out in an increased temperature using a mixture of solvents from the group of polyhydroxy alcohols, including glycerine, ethylene glycol i propylene glycol in the presence of P-toluenesulfonic acid as a catalyst.

- The liquefaction reaction was carried out for 2 h at 130-140°C.
- The mixture was diluted with a dioxane/water solution (4:1 v/v) after the reaction was finished.
- The product was separated from the solid residues by vacuum filtration.
- The residues were rinsed with the dioxane and oven dried at 103°C for 24 h.
- The water and dioxane were evaporated under reduced pressure.

Janiszewska D., Frąckowiak I., Mytko K. (2016) Exploitation of liquefied wood waste for binding recycled wood particleboards ,Holzforschung, DOI 10.1515/hf-2016-0043

Panels manufacturing



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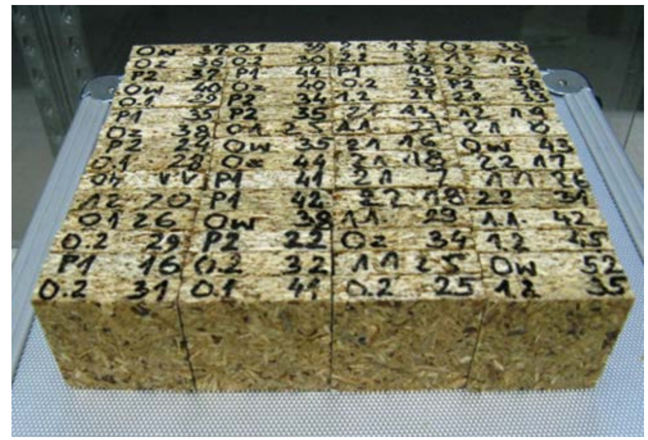


The post-consumer wood was used for particleboards production. Single-layer particleboards produced with the use of recycled wood and bonded with the UF resin modified by liquefied wood (up to 20%) were manufacture in the Wood Technology Institute in Poznan.

Samples characterization

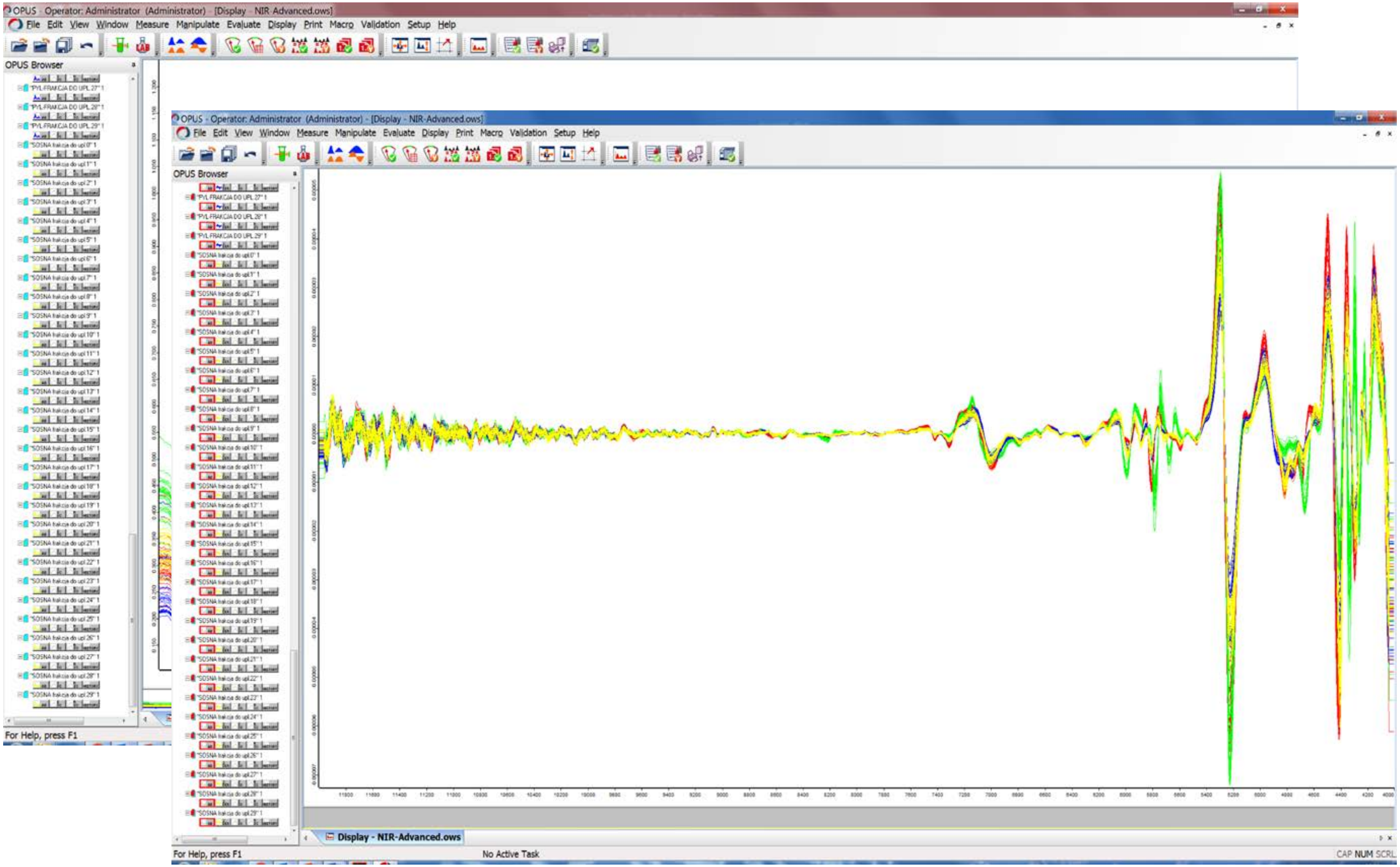
- **FT-NIR**
- **ED-XRF**
- **Portable NIR**
- FT-IR
- Hyperspectral imaging
- Wettablility
- Roughness

FT-NIR and XRF

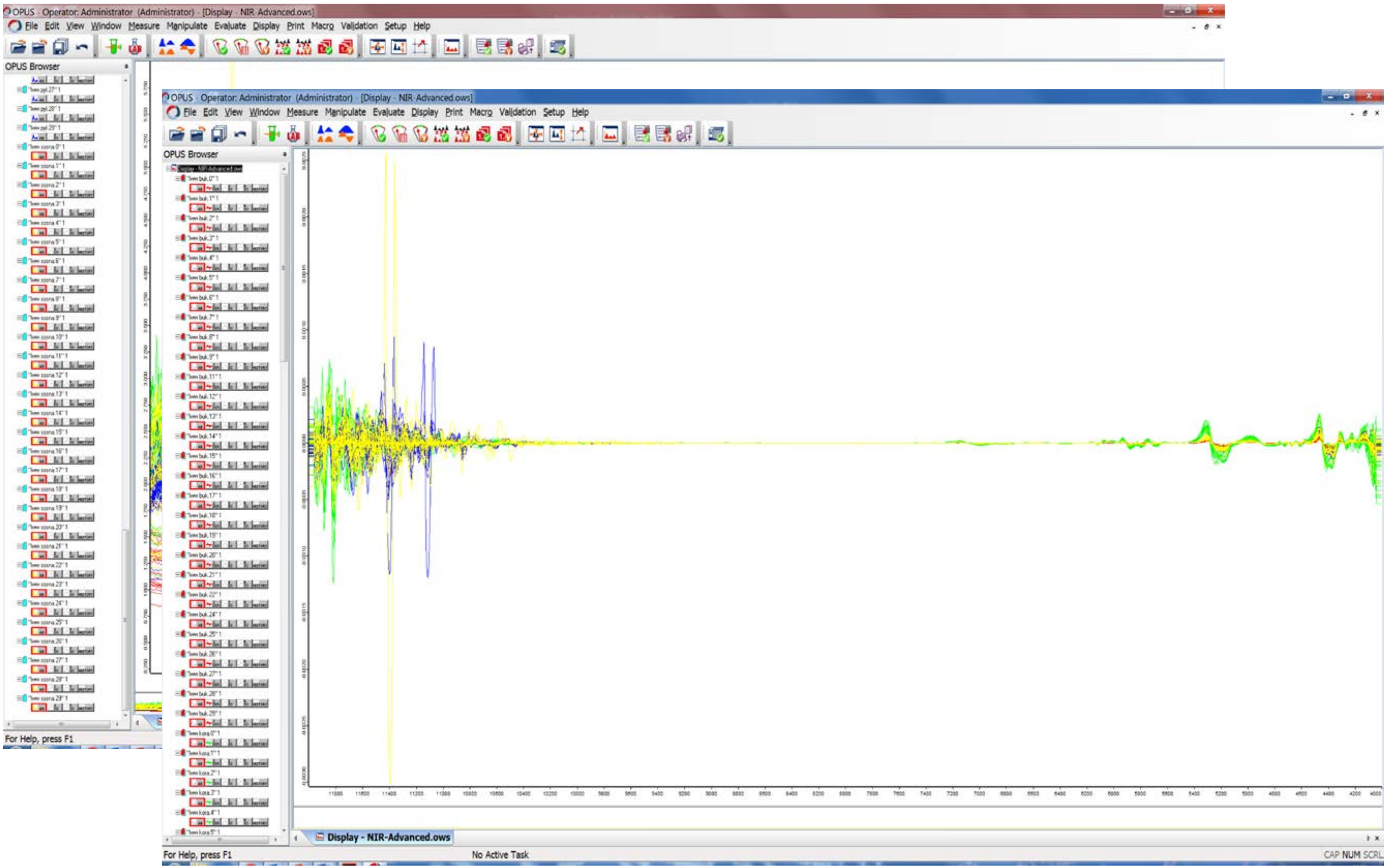
VECTOR 22-N FT-NIR (Bruker Optics GmBH)
spectral range: 4000cm - 12000cm^{-1}
spectra pre-processing: derivatives (Savitzky-Golay algorithm, 2nd polynomial order, 17 smoothing points) + VN.
OPUS 7.0 (Bruker Optics GmBH) used for data processing and mining.

portable XRF, X-MET5100 (Oxford Instruments plc)
The X-ray tube of the instrument was energized with a voltage of 45 kV and a current intensity of 40 μA.
Each sample was scanned for 60 seconds
level of accuracy - approximately 300.000 interior counts for each average value.

NIR spectra – raw materials



NIR spectra – liquefied wood



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11216,54	2,98E-06	-3,96E-06	4,68E-06	-6,29E-06	-7,38E-06
11212,69	1,84E-06	-1,98E-06	3,14E-06	-4,7E-06	-5,96E-06
11208,83	1,2E-06	1,34E-08	1,7E-06	-3E-06	-3,79E-06
11204,97	6,7E-07	1,39E-06	7,06E-07	-1,09E-06	-2,89E-06
11201,12	-5,58E-07	2,37E-06	-1,98E-07	1,12E-06	-2,74E-06
11197,26	-2,42E-06	3,24E-06	-1,39E-06	3,42E-06	-1,37E-06
11193,4	-3,65E-06	3,79E-06	-2,31E-06	5,5E-06	1,75E-06
11189,54	-3,71E-06	3,93E-06	-2,48E-06	6,5E-06	5,48E-06
11185,69	-3,36E-06	3,73E-06	-2,15E-06	6,27E-06	7,45E-06
11181,83	-2,59E-06	3,18E-06	-1,27E-06	5,8E-06	6,19E-06
11177,97	-1,11E-06	2,69E-06	-4,1E-07	5,54E-06	3,52E-06
11174,12	3,77E-07	2,52E-06	-1,92E-07	4,43E-06	1,39E-06
11170,26	1,27E-06	2,02E-06	-1,1E-07	1,91E-06	-1,38E-06
11166,4	1,61E-06	9,27E-07	6,8E-09	-6,16E-07	-4,84E-06
11162,54	1,71E-06	2,68E-07	1,72E-08	-1,74E-06	-6,09E-06
11158,69	1,89E-06	7,29E-07	1,21E-07	-1,71E-06	-4,26E-06
11154,83	1,91E-06	1,54E-06	-8,06E-08	-1,55E-06	-1,28E-06
11150,97	1,38E-06	1,91E-06	-8,32E-07	-1,47E-06	1,35E-06
11147,12	5,42E-07	1,83E-06	-1,18E-06	-8,82E-07	3,04E-06
11143,26	4,53E-08	1,26E-06	-5,33E-07	-6,16E-07	3,27E-06
11139,4	-1,06E-07	-1,44E-07	1,04E-07	-1,97E-06	2,54E-06
11135,54	-3,02E-07	-2,15E-06	-9,26E-08	-3,91E-06	2,47E-06
11131,69	-5,26E-07	-4,16E-06	-6,26E-07	-5,14E-06	2,91E-06
11127,83	-8,12E-07	-5,67E-06	-9,87E-07	-5,59E-06	2,01E-06

11382,4	-1,78E-06	1,48E-06	-7,5E-07	-1,39E-06	-6,75E-06
11378,54	-2,2E-07	1,48E-06	2,56E-07	-1,14E-06	-7,87E-06
11374,69	1,37E-06	1,2E-06	1,51E-06	-5,35E-07	-7,82E-06
11370,83	2,35E-06	8,1E-08	2,43E-06	2,77E-07	-5,29E-06
11366,97	2,85E-06	-8,2E-07	3,2E-06	2,49E-06	4,6E-07
11363,12	2,91E-06	-8,24E-07	3,4E-06	4,99E-06	7,01E-06
11359,26	2,6E-06	-9,45E-07	2,66E-06	5,18E-06	1,02E-05
11355,4	2,21E-06	-2,29E-06	1,43E-06	3,26E-06	7,83E-06
11351,54	1,14E-06	-3,86E-06	-5,78E-07	1,41E-06	2,49E-06
11347,69	-1,1E-06	-3,84E-06	-3,7E-06	3,02E-07	-6,54E-07
11343,83	-2,91E-06	-1,93E-06	-6,06E-06	-5,22E-07	4,49E-08
11339,97	-2,69E-06	8,6E-07	-5,7E-06	-6,25E-07	1,28E-06
11336,12	-1,03E-06	3,37E-06	-3,08E-06	3,23E-07	1,05E-06
11332,26	4,87E-07	4,49E-06	-2,53E-07	8,42E-07	9,15E-08
11328,4	9,16E-07	3,76E-06	1E-06	-7,84E-07	-1,72E-06
11324,54	8,93E-07	1,99E-06	1,3E-06	-3,9E-06	-4,09E-06
11320,69	1,74E-06	7,13E-07	2,46E-06	-6,47E-06	-5,53E-06
11316,83	3,27E-06	7,03E-07	3,97E-06	-7,37E-06	-4,99E-06
11312,97	3,82E-06	1,09E-06	4,05E-06	-6,37E-06	-2,53E-06
11309,12	2,51E-06	8,56E-07	2,68E-06	-3,81E-06	6,84E-08
11305,26	6,46E-07	5,1E-09	1,2E-06	-1,59E-06	1,43E-06
11301,4	-7,48E-08	-1,37E-06	3,06E-07	-1,79E-06	1,65E-06
11297,54	1,12E-07	-2,94E-06	-4,32E-07	-3,4E-06	8,21E-07
11293,69	3,23E-08	-3,87E-06	-1,3E-06	-3,25E-06	-2E-07
11289,83	-2,5E-07	-3,75E-06	-1,56E-06	-8,01E-07	1,68E-07
11285,97	1,12E-07	-2,91E-06	-2,9E-07	1,47E-06	2,01E-06
11282,12	9,86E-07	-1,78E-06	1,9E-06	2,22E-06	3,42E-06
11278,26	1,22E-06	-5,37E-07	3,09E-06	2,66E-06	3,36E-06
11274,4	4,17E-07	3E-07	2,65E-06	3,43E-06	3,07E-06
11270,54	-5,28E-07	3,78E-07	1,57E-06	3,28E-06	2,81E-06
11266,69	-8,57E-07	2,74E-07	3,78E-07	1,81E-06	1,92E-06
11262,83	-7,25E-07	8,58E-07	-8,41E-07	5,09E-07	9,22E-07
11258,97	-7,78E-07	2,13E-06	-2,12E-06	3,67E-07	7,82E-07
11255,12	-1,6E-06	3,05E-06	-3,68E-06	1,08E-06	2,19E-06
11251,26	-3,1E-06	2,97E-06	-5,32E-06	2,21E-06	4,57E-06
11247,4	-4,37E-06	2,29E-06	-6,17E-06	3,01E-06	5,81E-06
11243,54	-4,38E-06	1,07E-06	-5,23E-06	2,68E-06	4,7E-06
11239,69	-3,01E-06	-8,1E-07	-2,84E-06	1,45E-06	2,12E-06
11235,83	-1,22E-06	-2,38E-06	-4,52E-07	3,51E-07	6,91E-08
11231,97	3,19E-07	-3E-06	1,34E-06	-3,03E-07	-9,44E-07
11228,12	1,94E-06	-3,58E-06	3,04E-06	-1,55E-06	-2,29E-06
11224,26	3,47E-06	-4,55E-06	4,69E-06	-4,13E-06	-4,43E-06
11220,4	3,87E-06	-4,94E-06	5,41E-06	-6,37E-06	-6,58E-06
11216,54	2,98E-06	-3,96E-06	4,68E-06	-6,29E-06	-7,38E-06
11212,69	1,84E-06	-1,98E-06	3,14E-06	-4,7E-06	-5,96E-06
11208,83	1,2E-06	1,34E-08	1,7E-06	-3E-06	-3,79E-06
11204,97	6,7E-07	1,39E-06	7,06E-07	-1,09E-06	-2,89E-06
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11197,26	-2,42E-06	3,24E-06	-1,39E-06	3,42E-06	-1,37E-06
11193,4	-3,65E-06	3,79E-06	-2,31E-06	5,5E-06	1,75E-06
11189,54	-3,71E-06	3,93E-06	-2,48E-06	6,5E-06	5,48E-06
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11177,97	-1,11E-06	2,69E-06	-4,1E-07	5,54E-06	3,52E-06
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11170,26	1,27E-06	2,02E-06	-1,1E-07	1,91E-06	-1,38E-06
11166,4	1,61E-06	9,27E-07	6,8E-09	-6,16E-07	-4,84E-06
11162,54	1,71E-06	2,68E-07	1,72E-08	-1,74E-06	-6,09E-06
11158,69	1,89E-06	7,29E-07	1,21E-07	-1,71E-06	-4,26E-06
11154,83	1,91E-06	1,54E-06	-8,06E-08	-1,55E-06	-1,28E-06
11150,97	1,38E-06	1,91E-06	-8,32E-07	-1,47E-06	1,35E-06
11147,12	5,42E-07	1,83E-06	-1,18E-06	-8,82E-07	3,04E-06
11143,26	4,53E-08	1,26E-06	-5,33E-07	-6,16E-07	3,27E-06
11139,4	-1,06E-07	-1,44E-07	1,04E-07	-1,97E-06	2,54E-06
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11131,69	-5,26E-07	-4,16E-06	-6,26E-07	-5,14E-06	2,91E-06
11127,83	-8,12E-07	-5,67E-06	-9,87E-07	-5,59E-06	2,01E-06
11123,97	-1,07E-06	-5,99E-06	-9,32E-07	-4,77E-06	-5,5E-07
11120,12	-8,48E-07	-5E-06	-3,8E-07	-2,78E-06	-3,55E-06
11116,26	-4,42E-07	-3,67E-06	5,93E-08	-1,08E-06	-5,78E-06
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11104,69	-7,89E-07	-1,09E-07	8,34E-07	2,7E-06	-5,51E-06
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11085,4	2,36E-06	3,12E-06	2,69E-06	2,96E-06	5,55E-06
11081,54	2,22E-06	2,63E-06	2,18E-06	1,91E-06	5,3E-06
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11312,97	3,82E-06	1,09E-06	4,05E-06	-6,37E-06	-2,53E-06
11309,12	2,51E-06	8,56E-07	2,68E-06	-3,81E-06	6,84E-08
11305,26	6,46E-07	5,1E-09	1,2E-06	-1,59E-06	1,43E-06
11301,4	-7,48E-08	-1,37E-06	3,06E-07	-1,79E-06	1,65E-06
11297,54	1,12E-07	-2,94E-06	-4,32E-07	-3,4E-06	8,21E-07
11293,69	3,23E-08	-3,87E-06	-1,3E-06	-3,25E-06	-2E-07
11289,83	-2,5E-07	-3,75E-06	-1,56E-06	-8,01E-07	1,68E-07
11285,97	1,12E-07	-2,91E-06	-2,9E-07	1,47E-06	2,01E-06
11282,12	9,86E-07	-1,78E-06	1,9E-06	2,22E-06	3,42E-06
11278,26	1,22E-06	-5,37E-07	3,09E-06	2,66E-06	3,36E-06
11274,4	4,17E-07	3E-07	2,65E-06	3,43E-06	3,07E-06
11270,54	-5,28E-07	3,78E-07	1,57E-06	3,28E-06	2,81E-06
11266,69	-8,57E-07	2,74E-07	3,78E-07	1,81E-06	1,92E-06
11262,83	-7,25E-07	8,58E-07	-8,41E-07	5,09E-07	9,22E-07
11258,97	-7,78E-07	2,13E-06	-2,12E-06	3,67E-07	7,82E-07
11255,12	-1,6E-06	3,05E-06	-3,68E-06	1,08E-06	2,19E-06
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11247,4	-4,37E-06	2,29E-06	-6,17E-06	3,01E-06	5,81E-06
11243,54	-4,38E-06	1,07E-06	-5,23E-06	2,68E-06	4,7E-06
11239,69	-3,01E-06	-8,1E-07	-2,84E-06	1,45E-06	2,12E-06
11235,83	-1,22E-06	-2,38E-06	-4,52E-07	3,51E-07	6,91E-08
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11228,12	1,94E-06	-3,58E-06	3,04E-06	-1,55E-06	-2,29E-06
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11158,69	1,89E-06	7,29E-07	1,21E-07	-1,71E-06	-4,26E-06
11154,83	1,91E-06	1,54E-06	-8,06E-08	-1,55E-06	-1,28E-06
11150,97	1,38E-06	1,91E-06	-8,32E-07	-1,47E-06	1,35E-06
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11116,26	-4,42E-07	-3,67E-06	5,93E-08	-1,08E-06	-5,78E-06
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11104,69	-7,89E-07	-1,09E-07	8,34E-07	2,7E-06	-5,51E-06
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11093,12	2,85E-06	3,73E-06	2,99E-06	3,65E-06	2,06E-06
11089,26	2,75E-06	3,36E-06	2,87E-06	3,13E-06	3,89E-06
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11081,54	2,22E-06	2,63E-06	2,18E-06	1,91E-06	5,3E-06
11077,69	1,4E-06	1,3E-06	5,32E-07	-4,23E-07	2,2E-06
11073,83	-4,44E-07	-4,48E-07	-1,61E-06	-2,86E-06	-1,44E-06
11069,97	-1,92E-06	-1,73E-06	-2,7E-06	-4,26E-06	-3,6E-06
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11062,26	-1,35E-06	-1E-06	-1,45E-06	-3,07E-06	-2,58E-06
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11050,69	-7,57E-07	1,07E-06	-1,09E-06	1,83E-06	2,97E-06
11046,83	-1,23E-06	1,05E-06	-1,68E-06	2,43E-06	2,02E-06
11042,97	-1,22E-06	8,26E-07	-1,87E-06	2,21E-06	1,97E-07
11039,12	-4,57E-07	8,96E-08	-1,2E-06	1,75E-06	1,15E-07
11035,26	3,08E-07	-6,7E-07	-8,2E-09	1,39E-06	2,03E-06
11031,4	4,35E-07	-1,14E-06	7,6E-07	6,79E-07	3,82E-06
11027,54	2,7E-07	-1,2E-06	6,69E-07	-6,2E-08	4,05E-06
11023,69	4,45E-07	-8,16E-07	2,52E-07	-5,26E-07	1,92E-06
11019,83	5,64E-07	-4,67E-07	-1,9E-07	-1,66E-06	-2,69E-06
11015,97	1,34E-07	-3,25E-07	-5,76E-07	-3,21E-06	-7,07E-06
11012,12	1,24E-07	-1,88E-07	-1,34E-07	-3,5E-06	-8,2E-06
11008,26	1,39E-06	6,71E-08	1,45E-06	-1,93E-06	-6,67E-06
11004,4	3,03E-06	5,88E-07	3,18E-06	5,62E-07	-3,87E-06
11000,54	3,93E-06	1,13E-06	4,4E-06	2,39E-06	1,19E-07
10996,69	4,01E-06	1,17E-06	5,08E-06	2,98E-06	4,45E-06
10992,83	3,32E-06	8,62E-07	4,62E-06	2,92E-06	7,31E-06
10988,97	1,69E-06	7,72E-07	2,79E-06	2,08E-06	6,85E-06
10985,12	-4,76E-07	7,94E-07	5,63E-07	3,24E-07	3,4E-06
10981,26	-2,2E-06	4,13E-07	-9,28E-07	-8,47E-07	7,43E-07
10977,4	-3,05E-06	-7,37E-08	-1,34E-06	-2,23E-07	1,41E-06

11158,69	1,89E-06	7,29E-07	1,21E-07	-1,71E-06	-4
11154,83	1,91E-06	1,54E-06	-8,06E-08	-1,55E-06	-1
11150,97	1,38E-06	1,91E-06	-8,32E-07	-1,47E-06	1
11147,12	5,42E-07	1,83E-06	-1,18E-06	-8,82E-07	3
11143,26	4,53E-08	1,26E-06	-5,33E-07	-6,16E-07	3
11139,4	-1,06E-07	-1,44E-07	1,04E-07	-1,97E-06	2
11135,54	-3,02E-07	-2,15E-06	-9,26E-08	-3,91E-06	2
11131,69	-5,26E-07	-4,16E-06	-6,26E-07	-5,14E-06	2
11127,83	-8,12E-07	-5,67E-06	-9,87E-07	-5,59E-06	2
11123,97	-1,07E-06	-5,99E-06	-9,32E-07	-4,77E-06	-
11120,12	-8,48E-07	-5E-06	-3,8E-07	-2,78E-06	-3
11116,26	-4,42E-07	-3,67E-06	5,93E-08	-1,08E-06	-5
11112,4	-5,25E-07	-2,73E-06	1,25E-07	-1,4E-07	-6
11108,54	-8,82E-07	-1,73E-06	3,38E-07	1,02E-06	-6
11104,69	-7,89E-07	-1,09E-07	8,34E-07	2,7E-06	-5
11100,83	1,98E-07	1,95E-06	1,56E-06	4,09E-06	-3
11096,97	1,79E-06	3,46E-06	2,49E-06	4,35E-06	-2
11093,12	2,85E-06	3,73E-06	2,99E-06	3,65E-06	2
11089,26	2,75E-06	3,36E-06	2,87E-06	3,13E-06	3
11085,4	2,36E-06	3,12E-06	2,69E-06	2,96E-06	5
11081,54	2,22E-06	2,63E-06	2,18E-06	1,91E-06	
11077,69	1,4E-06	1,3E-06	5,32E-07	-4,23E-07	
11073,83	-4,44E-07	-4,48E-07	-1,61E-06	-2,86E-06	-1
11069,97	-1,92E-06	-1,73E-06	-2,7E-06	-4,26E-06	-
11066,12	-2,03E-06	-1,96E-06	-2,35E-06	-4,28E-06	-
11062,26	-1,35E-06	-1E-06	-1,45E-06	-3,07E-06	-2
11058,4	-7,96E-07	3,84E-07	-7,88E-07	-1,24E-06	3
11054,54	-5,68E-07	1,08E-06	-6,75E-07	5,17E-07	
11050,69	-7,57E-07	1,07E-06	-1,09E-06	1,83E-06	2
11046,83	-1,23E-06	1,05E-06	-1,68E-06	2,43E-06	2
11042,97	-1,22E-06	8,26E-07	-1,87E-06	2,21E-06	1
11039,12	-4,57E-07	8,96E-08	-1,2E-06	1,75E-06	1
11035,26	3,08E-07	-6,7E-07	-8,2E-09	1,39E-06	2
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11027,54	2,7E-07	-1,2E-06	6,69E-07	-6,2E-08	4
11023,69	4,45E-07	-8,16E-07	2,52E-07	-5,26E-07	1
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11015,97	1,34E-07	-3,25E-07	-5,76E-07	-3,21E-06	-7
11012,12	1,24E-07	-1,88E-07	-1,34E-07	-3,5E-06	-
11008,26	1,39E-06	6,71E-08	1,45E-06	-1,93E-06	-6
11004,4	3,03E-06	5,88E-07	3,18E-06	5,62E-07	-3
11000,54	3,93E-06	1,13E-06	4,4E-06	2,39E-06	1
10996,69	4,01E-06	1,17E-06	5,08E-06	2,98E-06	4
10992,83	3,32E-06	8,62E-07	4,62E-06	2,92E-06	7
10988,97	1,69E-06	7,72E-07	2,79E-06	2,08E-06	6
10985,12	-4,76E-07	7,94E-07	5,63E-07	3,24E-07	
10981,26	-2,2E-06	4,13E-07	-9,28E-07	-8,47E-07	7
10977,4	-3,05E-06	-7,37E-08	-1,34E-06	-2,23E-07	1
10973,54	-3,42E-06	-2,23E-07	-1,53E-06	8,23E-07	3
10969,69	-3,7E-06	-3,11E-07	-2,55E-06	5,46E-07	2
10965,83	-3,81E-06	-3,39E-07	-3,96E-06	-3,41E-07	9
10961,97	-3,6E-06	-2,67E-07	-4,52E-06	-7,02E-07	-1
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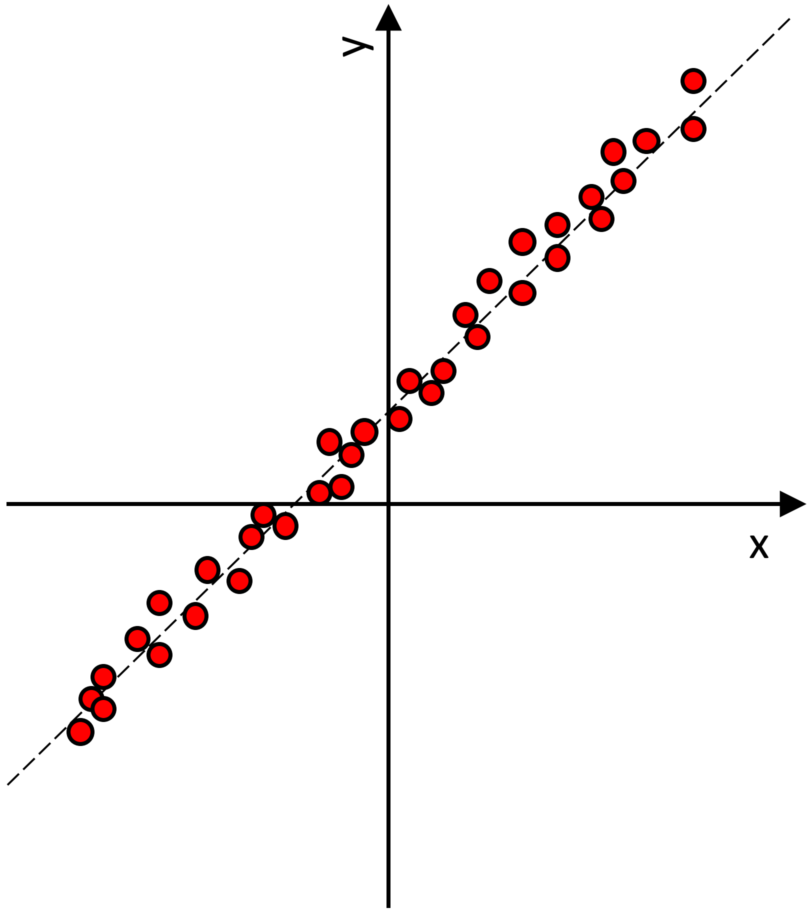
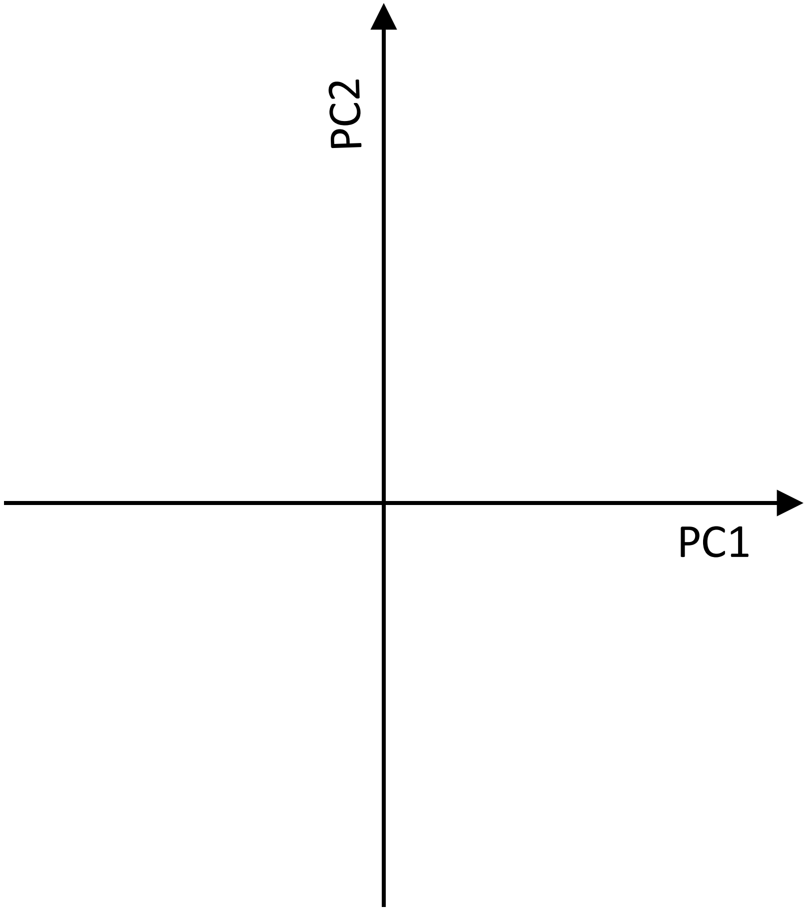
10954,26	-1,72E-06	-1,12E-06	-3,39E-06	-1,13E-06	-6
10950,4	4,65E-07	-1,8E-06	-1,66E-06	-1,19E-06	-5
10946,54	2,74E-06	-2,6E-06	5,55E-07	-1,35E-06	-3
10942,69	4,05E-06	-2,87E-06	2,45E-06	-1,51E-06	-1
10938,83	3,89E-06	-2,24E-06	3,41E-06	-1,35E-06	1
10934,97	2,39E-06	-1,26E-06	2,6E-06	-1,32E-06	
10931,12	2,11E-07	-3,83E-07	1,2E-07	-2E-06	5
10927,26	-1,65E-06	2,16E-07	-2,39E-06	-3,19E-06	-3
10923,4	-2,53E-06	3,95E-07	-3,36E-06	-3,84E-06	-5
10919,54	-2,43E-06	3,54E-07	-2,71E-06	-3,03E-06	-4
10915,69	-1,87E-06	4,68E-07	-1,44E-06	-1,54E-06	8
10911,83	-1,58E-06	8,24E-07	-5,91E-07	-2,6E-07	4
10907,97	-1,68E-06	1,2E-06	-3,93E-07	1,33E-06	8
10904,12	-1,44E-06	1,18E-06	-2,99E-07	2,95E-06	8
10900,26	-3,99E-07	4,91E-07	-1,04E-08	3,73E-06	6
10896,4	1,1E-06	-3,22E-07	3,73E-07	3,9E-06	2
10892,54	2,46E-06	-5,44E-07	9,64E-07	3,83E-06	5
10888,69	2,88E-06	-4,03E-07	1,54E-06	3,59E-06	-9
10884,83	1,84E-06	-3,02E-07	1,61E-06	3,36E-06	-1
10880,97	-2E-07	-2,98E-08	1,16E-06	3,24E-06	-1
10877,12	-2,24E-06	3,58E-07	1,82E-07	2,87E-06	-8
10873,26	-3,39E-06	4,02E-07	-1,04E-06	1,56E-06	-7
10869,4	-3,14E-06	1,22E-07	-1,47E-06	-3,17E-07	-8
10865,55	-1,84E-06	-1,29E-07	-5,2E-07	-1,94E-06	-1
10861,69	-4,59E-07	-2,74E-07	1,23E-06	-3,53E-06	-1
10857,83	5,57E-07	-2,66E-07	2,63E-06	-5,08E-06	-2
10853,97	1,39E-06	1,21E-07	2,93E-06	-5,52E-06	-1
10850,12	2,11E-06	8,83E-07	2,43E-06	-3,95E-06	1
10846,26	2,73E-06	1,71E-06	1,93E-06	-1,24E-06	5
10842,4	3,25E-06	2,35E-06	1,57E-06	8,27E-07	-9
10838,55	3,27E-06	2,79E-06	1,23E-06	2,23E-06	-8
10834,69	2,51E-06	2,95E-06	9,75E-07	3,5E-06	2
10830,83	9,95E-07	2,44E-06	3,81E-07	4,12E-06	5
10826,97	-9,53E-07	1,17E-06	-8,33E-07	3,87E-06	5

Multivariate data analysis

- **Exploratory data analysis** (data mining) – attempts to find the hidden structure in large complex data sets
  - Cluster analysis
  - Principal Component Analysis
- **Regression analysis and Predictive Models** (developing the models from available data and predict desired response)
  - Partial Least Squares Regression
  - Multiplicative Linear Regression
- **Classification Models** (separation of group of object into one or more classes based on distinguished characteristic)
  - Cluster Analysis Test
  - Identity Test
  - SIMCA

Principal Component Analysis

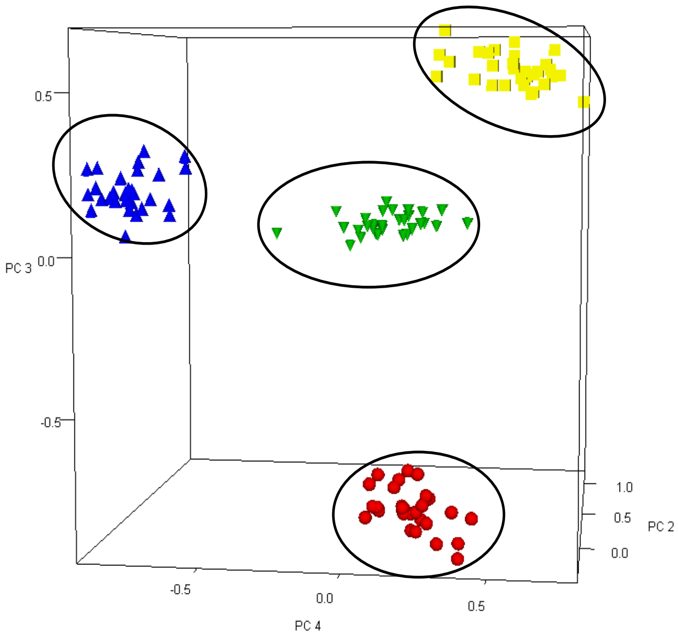




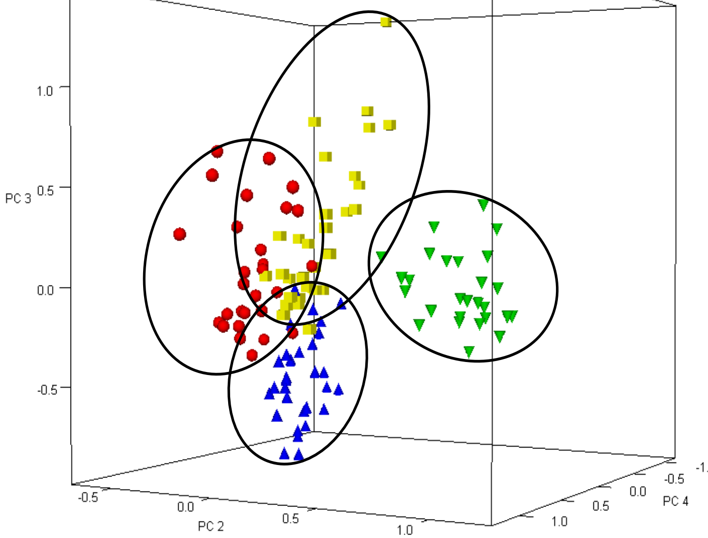
It is used for de-correlation of highly correlated data to reduce multidimensional data set to lower dimensions

it can separate set of input data into groups of peculiar similarities

Principal Component Analysis



raw materials

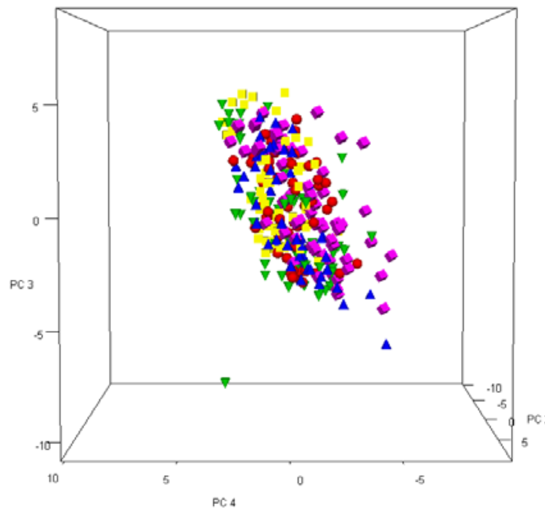


liquefied wood

Note: red = beech wood chips, yellow = pine wood chips, green = bark, blue = mixed hardwood/softwood industrial sawdust

PCA of panels

FT-NIR



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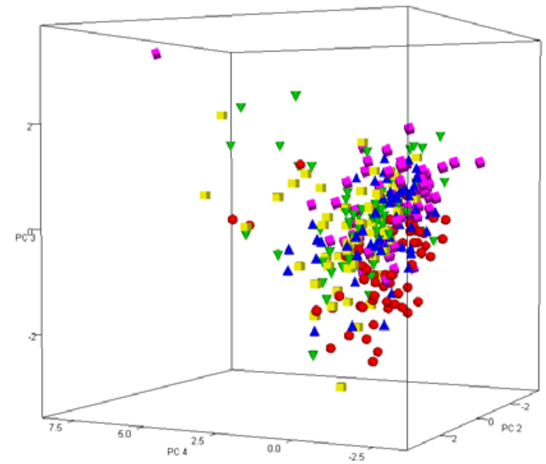
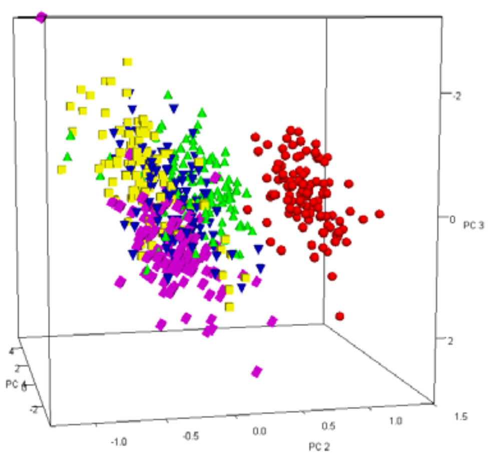


top



MicroNIR

XRF – raw materials

ED-XRF measurements, mg/kg								
	bark		**beech**		**pine**		**wood powder**	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
Ca	5352	139	1193	330	1801	281	960	222
Mn	99	6	283	21	268	19	103	13
Zn	13	1	14	4	38	4	16	2
Cu	10	1	16	5	46	5	25	3
Sr	7	0	–	–	–	–	–	–
Br	–	–	–	–	–	–	–	–

XRF – liquefied wood

ED-XRF measurements, mg/kg								
	bark		**beech**		**pine**		**wood powder**	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
Cr	–	–	49	4	34	4	20	4
Ni	18	1	24	1	14	1	29	1
Mn	12	2	23	3	14	3	9	2
Zn	4	0	3	0	8	0	2	0
Cu	4	0	6	0	8	0	3	0
Sr	2	0	2	0	1	0	1	0
Fe	–	–	–	–	607	5	–	–

Conclussions

- All investigated raw materials can be easily distinguished before liquefaction by NIR; however after the transformation process the same products become more homogenous from the chemical/spectroscopic point of view.
- This suggests that the type of wood waste used for liquefaction has relatively little effect on the resulting product.
- It seems that any kind of available wood waste might be used therefore as a primary material for liquefaction.
- XRF analysis did not detect harmful contaminations in raw materials and liquefied wood
- Current work is focused on the investigation of liquefied wood additions on the particleboard properties.

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Thank you

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