Inštitut za celulozo in papir
Pulp and paper Institute

Hemp fibers for production of speciality paper and board grades

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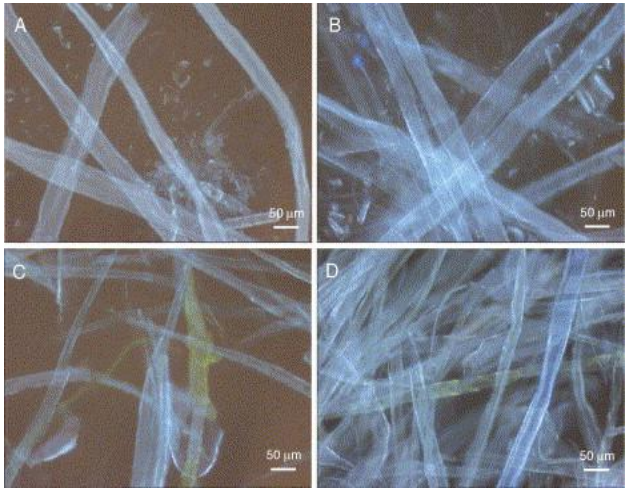
Papermaking fibers

Origin

- **Softwood** - spruce, fir, pine
- **Hardwood** - eucalyptus, aspen, birch
- **Annual plants** – hemp, flax, kenaf, bagasse, cotton, straw

Properties

- morphological
- chemical
- physical, mechanical
- optical



HEMP fibers in papermaking

- the oldest surviving piece of paper from hemp – China (140 – 87 B.C.)
- the first European papermaking in the 16th century
- until the 19th century - rags (hemp and flax fibers)
- growing need for paper - rag supply insufficient
- exploitation of wood – abundant and cheap
- today, only about 5 % of world s paper is made from annual plants (hemp, flax,…)

HEMP fibers in papermaking

- **renewed interest in hemp – environmental reasons**
- **excessive deforestation**
  (TREES - oxygen supply, CO_2 removal, natural balance)
- **1 t of PAPER – 3 t of WOOD - up to 17 TREES**
- **HEMP has about 4 times higher yield / hectare compared to TREES (20 years)**
- **TREES need 50-100 years to grow, HEMP can be cutivated in 100 days**

HEMP fibers in papermaking

	Hemp bast	Hemp core
cellulose	70 %	35 %
hemicellulose	15 %	35 %
lignin	5 %	23 %
length, mm	5 - 40	0,5
diameter, µm	25 - 50	22
thickness, µm	10 - 25	1,4

HEMP fibers in papermaking

hemp bast

hemp core

long fibers

short fibers

HEMP fibers – charactesristics

	WOOD		HEMP
cellulose	40 – 50 %		70 %
hemicellulose	25 – 35 %		15 %
lignin	25 – 35 %		5 %
Fibers	**SW**	**HW**	
length, mm	3 - 6	(0,5 - 1,8)	5 - 40
diameter, µm	25 - 45	(10 - 36)	25 - 50
thickness, µm	2 - 5	(3 - 6)	10 - 25

HEMP fibers in papermaking

- **bleaching** possible by environmentally friendly procedures (ozone, hydrogen peroxyde, oxygen)
- **less energy** needed for paper production compared to wood
- **paper resistant against ageing** (no change of colour, mechanical and chemical properties over centuries)
- **1 t of HEMP paper preserves 12 TREES!!!**

HEMP fibers in papermaking

- **hemp pulp mill 5000 t/year – wood pulp mill 250.000 t/year**
- **expensive production – small capacities**
- **hemp is harvested once a year**
  (storage needed, manual work with bundles, high costs)

HEMP pulping technology

- long hemp bast fibers are processed
- bales → digester, water is added (5 to 10 times fiber weight), cooking chemicals (NaOH, Na_2SO_3,…)
- digestion – up to 8 h, 175 C
- separation of fibers and washing → clean fibers
- beating (12 h) and bleaching → fibers ready for PAPERMAKING
- processing time (20 h) – costly equipment, expensive handling

Novel pulping techniques for annual plants

- **pulp production without chemicals**

  (high output, no pollution, low energy demand, low investment costs, cheap and easy to operate price)

- **HEMP PULP (ultrasound technology)**

  dr. Zsolt Nemeth – University of Budapest

- **Pulp and Paper Institute Ljubljana**

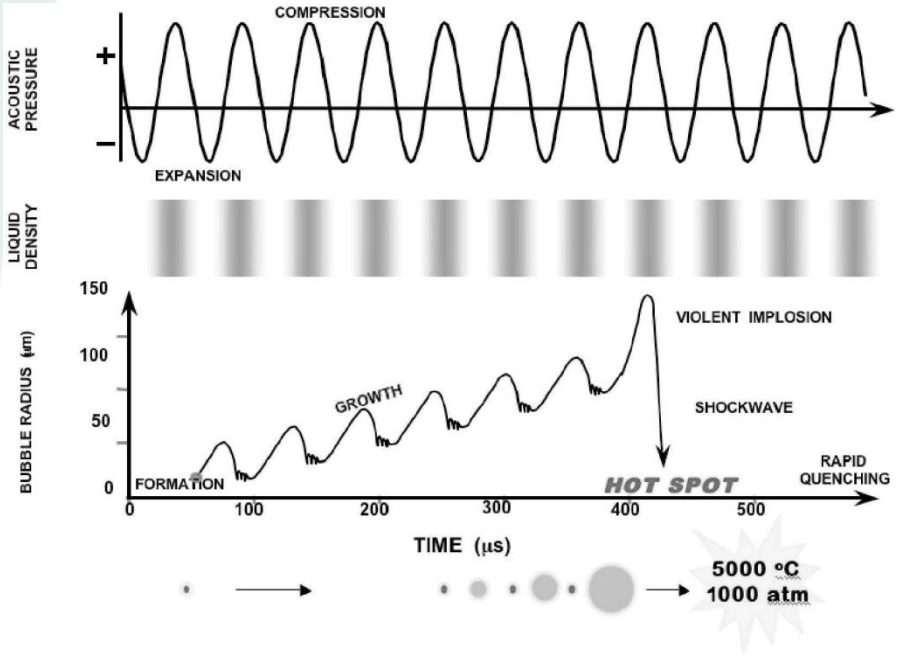
  (some preliminary tests were performed)

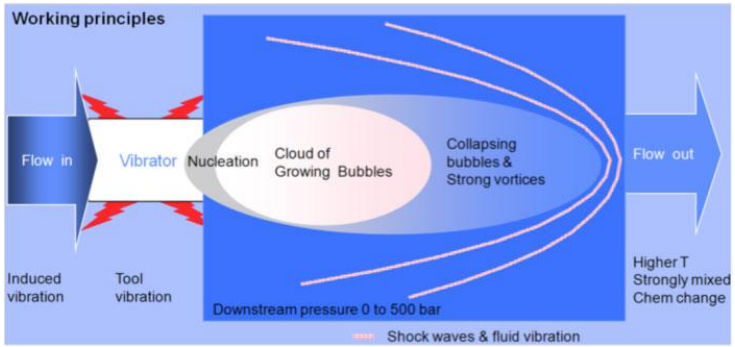
  - microscopy

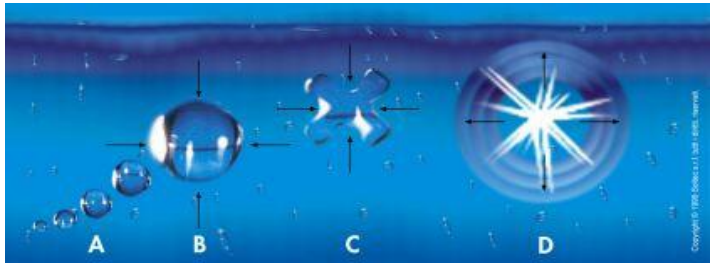
  - mechanical testing (fiber characteristics)

  - chemical testing

Ultrasonic (or hydrodynamic) cavitation







Ultrasonic (or hydrodynamic) cavitation

- **cavitation is formation of empty cavities in liquid and their subsequent implosion**

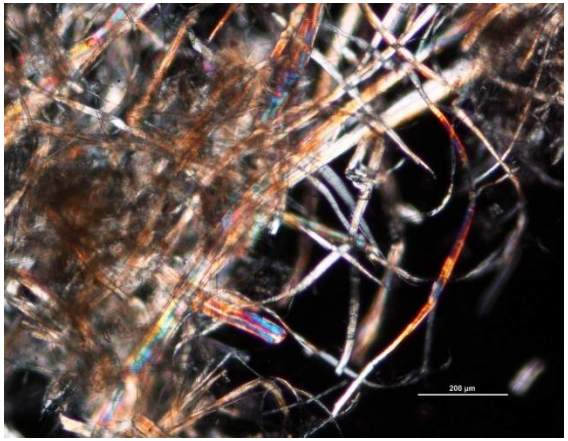
- **implosion of cavities**
  - **shock waves (100-300 m/s)**
  - **high temperature up to 5000 C**
  - **high pressure > 500 atm**
  - **formation of OH radicals (chemical reactions)**

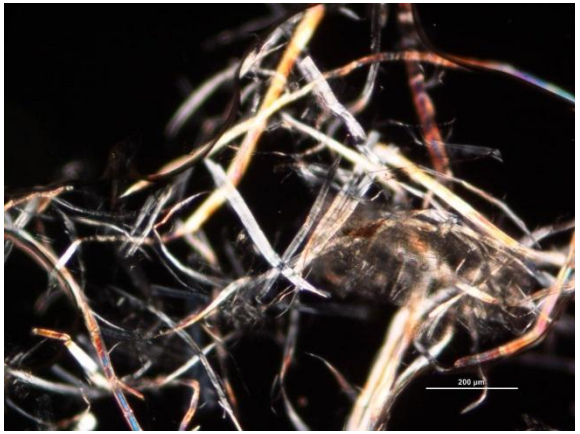
Practial use: emulsification, catalysis, homogenization, disaggregation, dispersion, production of nano-particles, water treatment, cleaning of surfaces

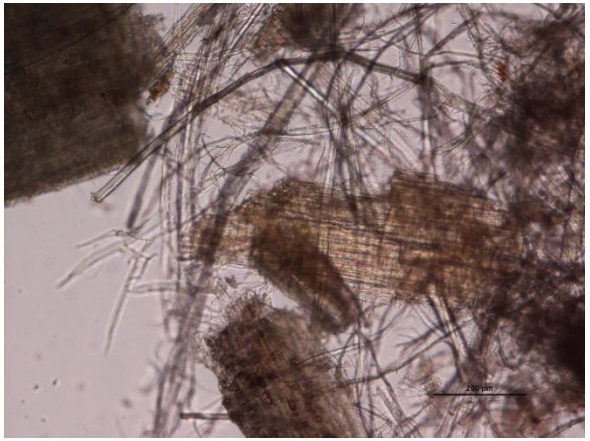
“Shark” shearing technology

- efficient cutting of particles
- low energy demand
- no waste generated
- no polluting chemicals
- no toxic byproducts
- cheap and easy to operate

Microscopy - results







Mechanical properties - results

- laboratory sheets from pulp suspension (Rapid Köthen)
- mechanical tests (fiber length, tensile length, tensile strength, break index, burst index, folding strength, air permeability)

Results indicate - some characteritstics similar or even better than usual papermaking fibers from wood!

Fiber screening and further refining needed - proper fiber characteristics for papermaking!

Chemical properties - results

- **pH value of fiber suspension – neutral**
- **viscosity - medium (degree of polymerisation of cellulose molecules quite high, long chains)**
- **ISO brightness (optical property) - low (lignin still present)**

Further chemical analyses still needed - characterisation of surface properties of fibers

Bleaching needed - characterisation of mechanical, chemical and optical properties of fibers after bleaching

EVALUATION of papermaking potential of fibers in accordance with sustainability concept!!!

Conclusions

- **hemp may be excellent substitute for wood cellulose fibers**
- **fiber quality highly depends on the pulping procedure**
- **“classical pulping processes” impact environment, expensive**
- **optimization of novel processes – good quality fibers, sustainable production**
- **small scale production of speciality papers – encouraged**
- **“hemp fibers” – durable and convenient for production of high quality archive, document and speciality art papers as well as security papers**

- **hemp fibers as papermaking raw material have potential, further research still needed – to produce durable paper at reasonable price**

Thanks for your attention!

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