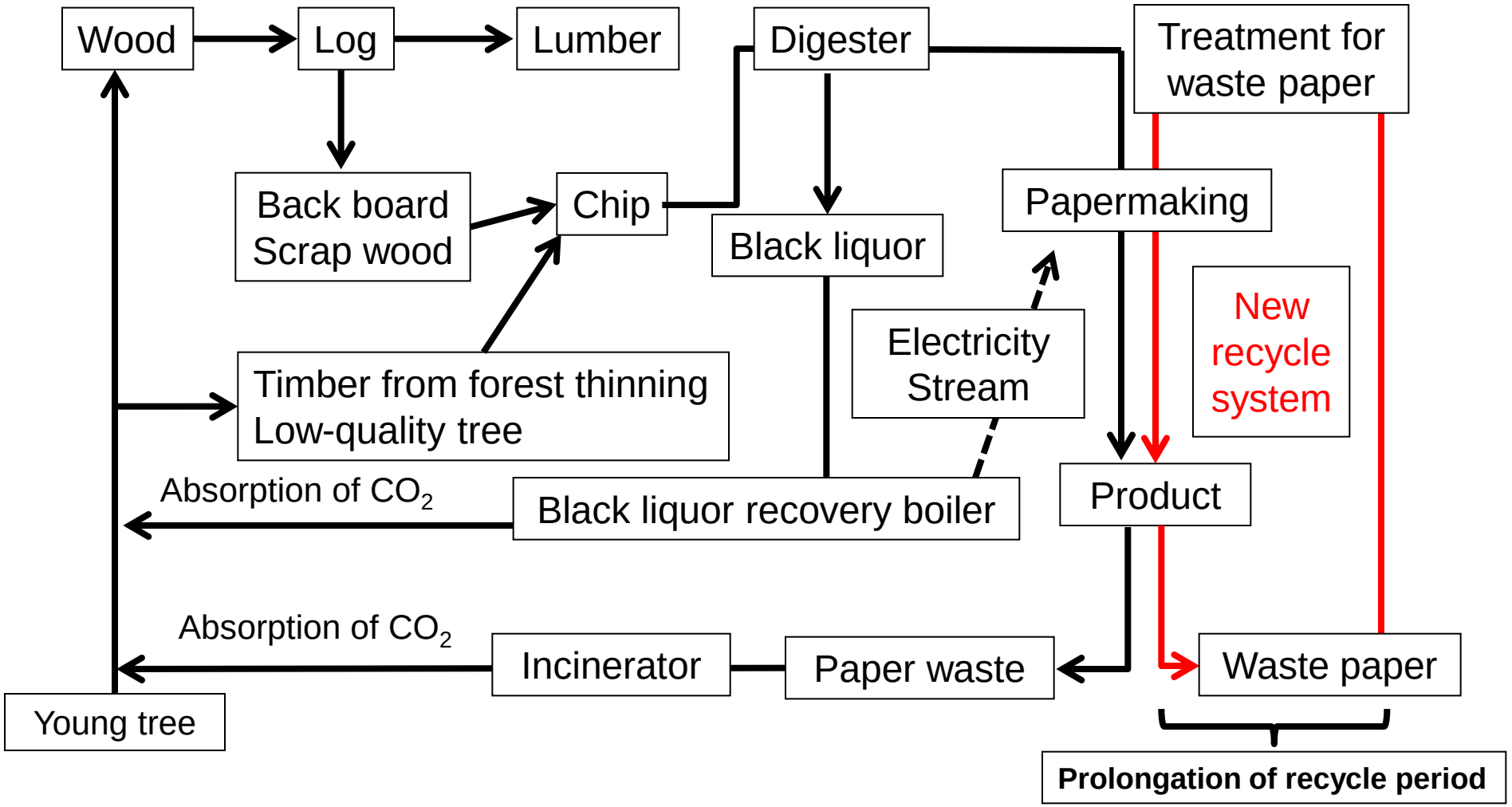
Position of new recycle system for waste paper in material cycle system

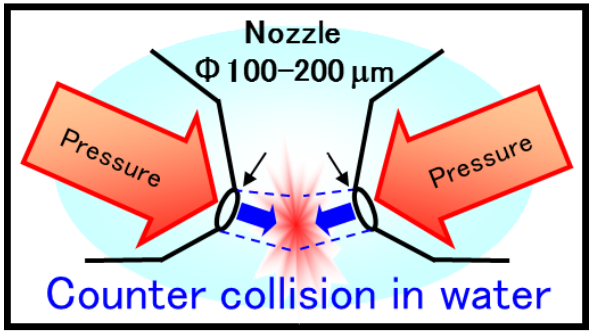


Reference: Oji Paper Co., Ltd., In *"Knowledge of paper 100"*, pp218-219, Tokyo Shoseki Co., Ltd., Japan (2009)

<< Development of new system for waste paper>>

Waste paper

Aqueous counter collision method (= ACC)

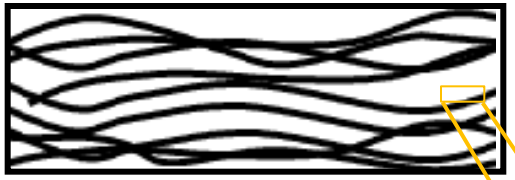


Miniaturization by rapid water stream

Cellulose nanofiber

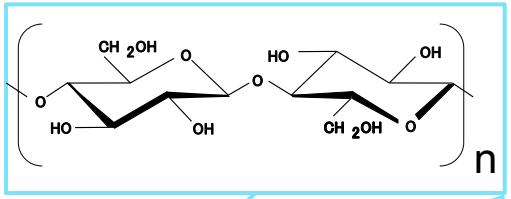
Ordered structure at micro-scale

< Recycle >
Separation and Refinement of impurity by ACC



Nanofiber-aligned material

Cellulose molecule



Nanofiber = molecule-aligned material

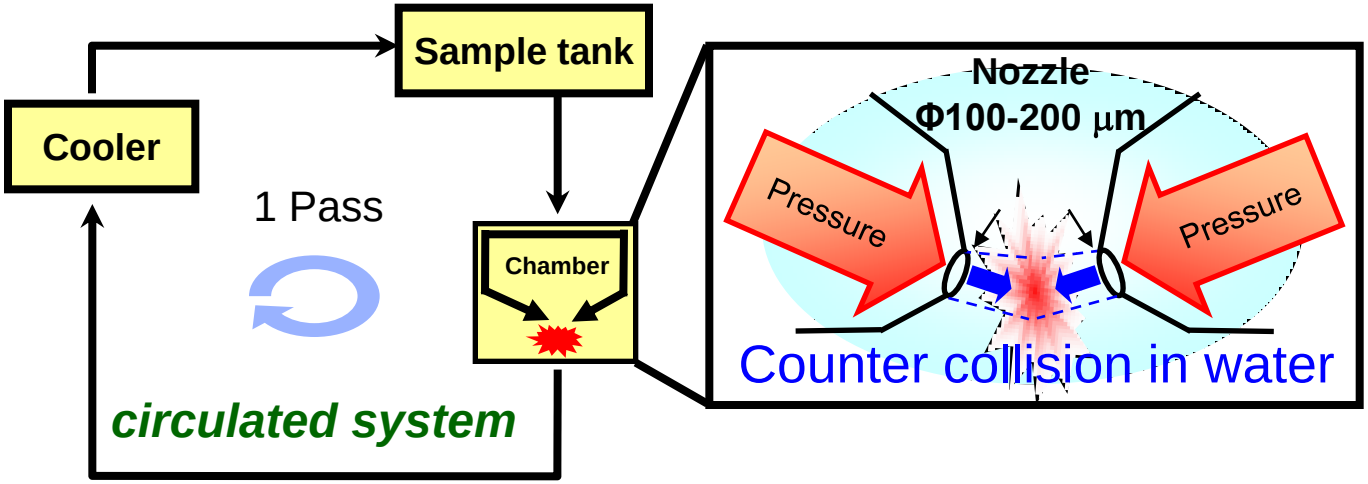
Agent strengthening paper

Water-resistant material

High-intensity material

New form of waste paper

Aqueous Counter Collision system (= ACC)[1)]



Properties of ACC

- **Cleavage of only intermolecular interactions** without chemically modifying molecules
- Liberating nano-fibers from raw materials
- A rapid process to provide nano-fibers
- Chemicals-free (using water alone)

Maximum bonding energy cleaved by ACC (Theoretical value)

18.1 kJ/mol^{-1}

Each bonding energy

Type of bond	Bonding energy / kJ mol^{-1}
H-OH（covalent bond）	499[2)]
H-H（covalent bond）	436[2)]
ion-ion	250[3)]
Medium hydrogen bond	21 – 62[4)]
Weak hydrogen bond	4.2×10^{-1} - 4.2[4)]
London dispersion force	2[3)]
dipole-dipole	0.6-2[3)]

1. Kondo T., Morita M., Hayakawa K., Onda Y., U.S. Patent 7,357,339.
2. K.P.C.Vollhardt, N.E.Schore, In *"Third edition organic chemistry structure and function"*, p99, Kagaku-Dojin Publishing Company,INC, Japan (1999)
3. P. W. Atkins, In *"Physical chemistry sixth edition"*, p716, Tokyo kagaku dojin Ltd., Japan (2001)
4. H. Uedaira, In *"Molecular engineering of water"*, p7, Kodansha Scientific Ltd., Japan (1998)

Important natural phenomena in new recycle system for waste paper

Waste paper

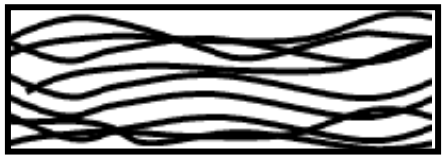
Aqueous counter collision method (= ACC)

Removal of water from CNF suspension

Cellulose nanofiber (= CNF)

Ordered structure at micro-scale

< Recycle >
Separation and Refinement of impurity by ACC



Nanofiber-aligned material

Hydrogen bond formation with repeating dry and wetting

Interaction between CNF and impurity

Agent strengthening paper

Water-resistant material

High-intensity material

New form of waste paper

Aggregation behavior of CNF with microfiber