Low temperature plasma for paper disinfection

Influence on the physico-chemical properties (preliminary study)

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The aim of the preliminary study

Influence of low temperature plasma to the:

- Mechanical properties of paper
- Optical properties of paper
- Chemical properties of paper
- Average degree of polymerization

Low temperature plasma treatment

Source of plasma:

- high-frequency multi-point corona (voltage 14–16 kV, current 0.5 mA, total power 7–8 W and frequency 130 kHz)

Apparatus:

- cubic box of the size 23 cm, corona burned on 13 point electrodes placed approximately 2 cm over the disinfected sample

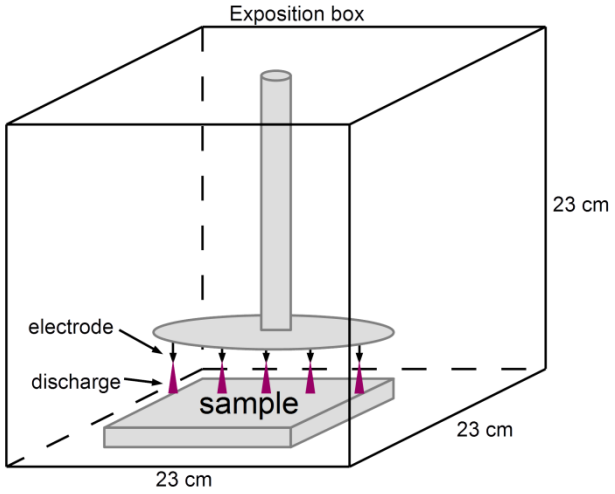
Temperature in the apparatus: 29 °C

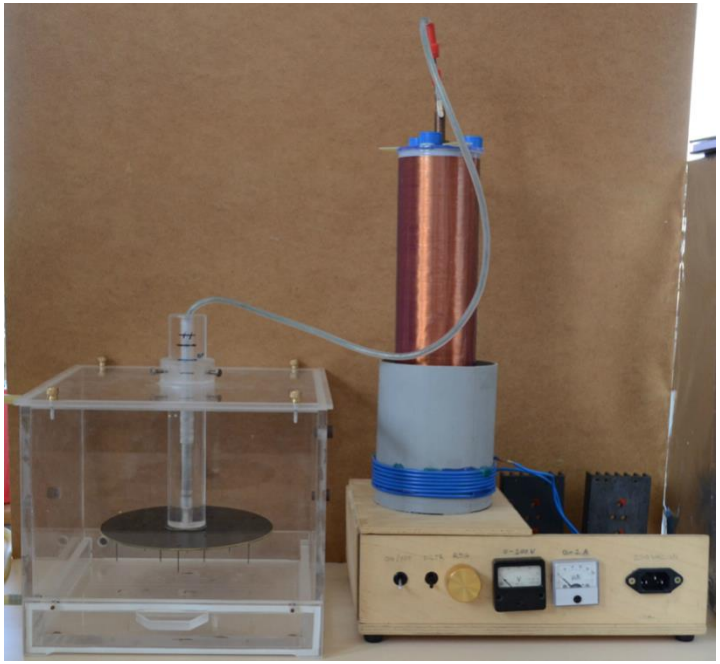
Time of samples treatment: 10, 20 and 30 minutes

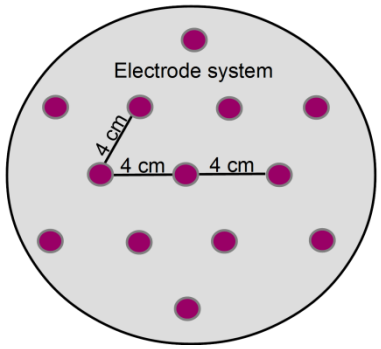
100% disinfection efficiency is achieved after 30 minutes of treatment by LTP

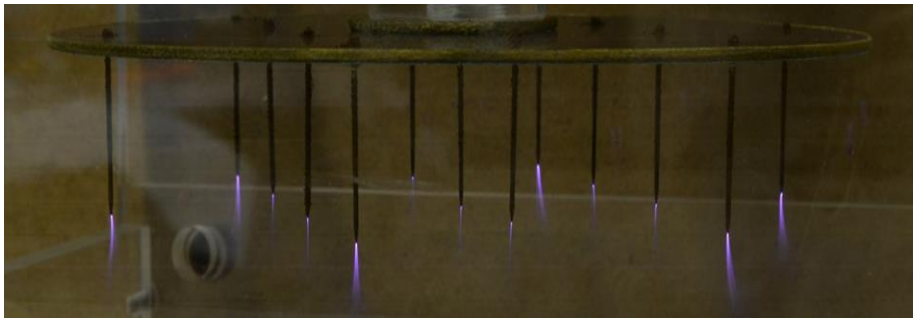
(Součková H.: The effect of corona discharge to the spores of mycromycetes. Bachelor thesis, UCT in Prague 2010.

Low temperature plasma apparatus









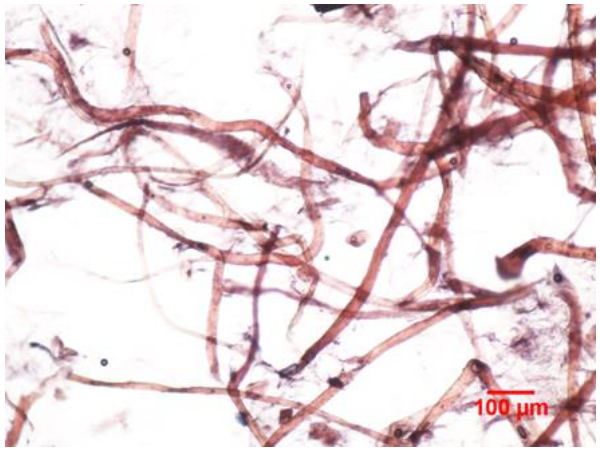
Studied paper

- Whatman Grade 1 for chromatography

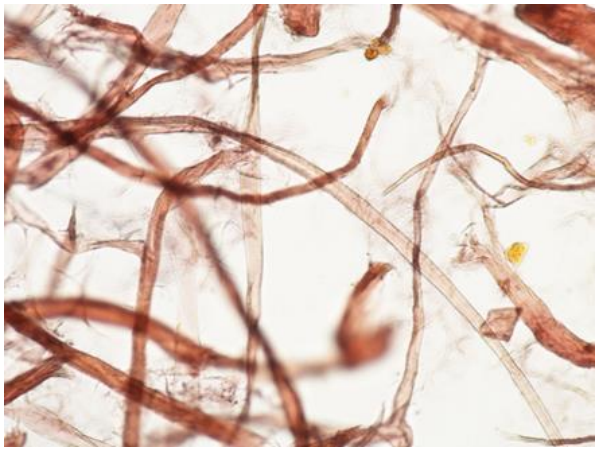
  grammage: 88 $g \cdot m^{-2}$

  pH of cold water extract: 5,20

  Fiber composition: 100 % cotton without additives



Herzberg's agent



Graff "C" dye

Artificial ageing of samples

- **Wet ageing** according ISO 5630/3 (80°C, 65% RH) for 15 days

  Chamber: Espec corp. PR-2KP (Japan)

- **Dry ageing** according ISO 5630/1 (105°C) for 6 days

  Chamber: Binder KBF 115 (Germany)

Methods of measurement

- **Optical properties**

  Parameters of CIElab color space

  Total color difference ΔE*

- **Mechanical properties**

  Breaking load (kN/m)

  Breaking length (km)

  Elongation (%)

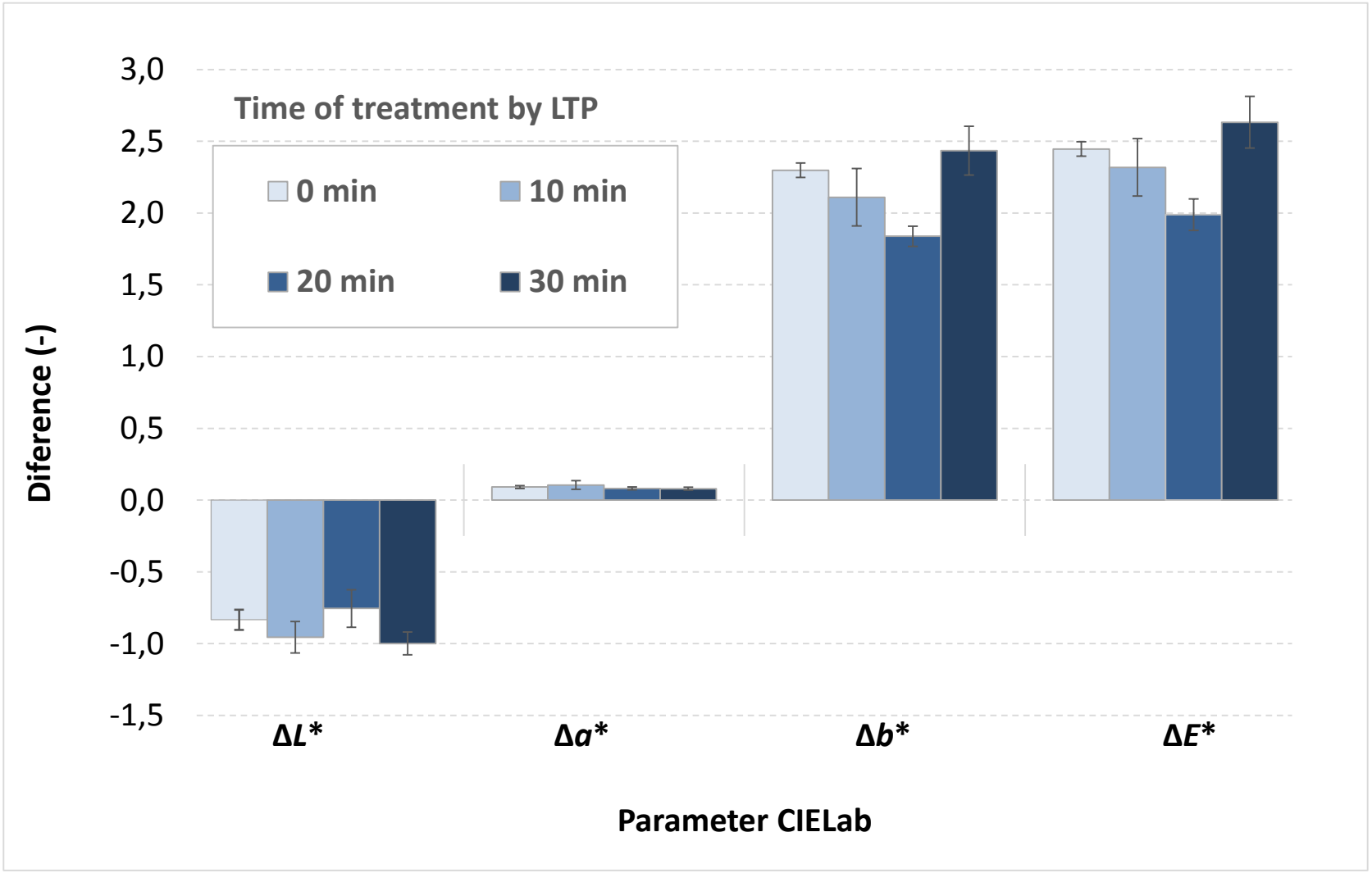
  Zero-span (N)

Methods of measurement

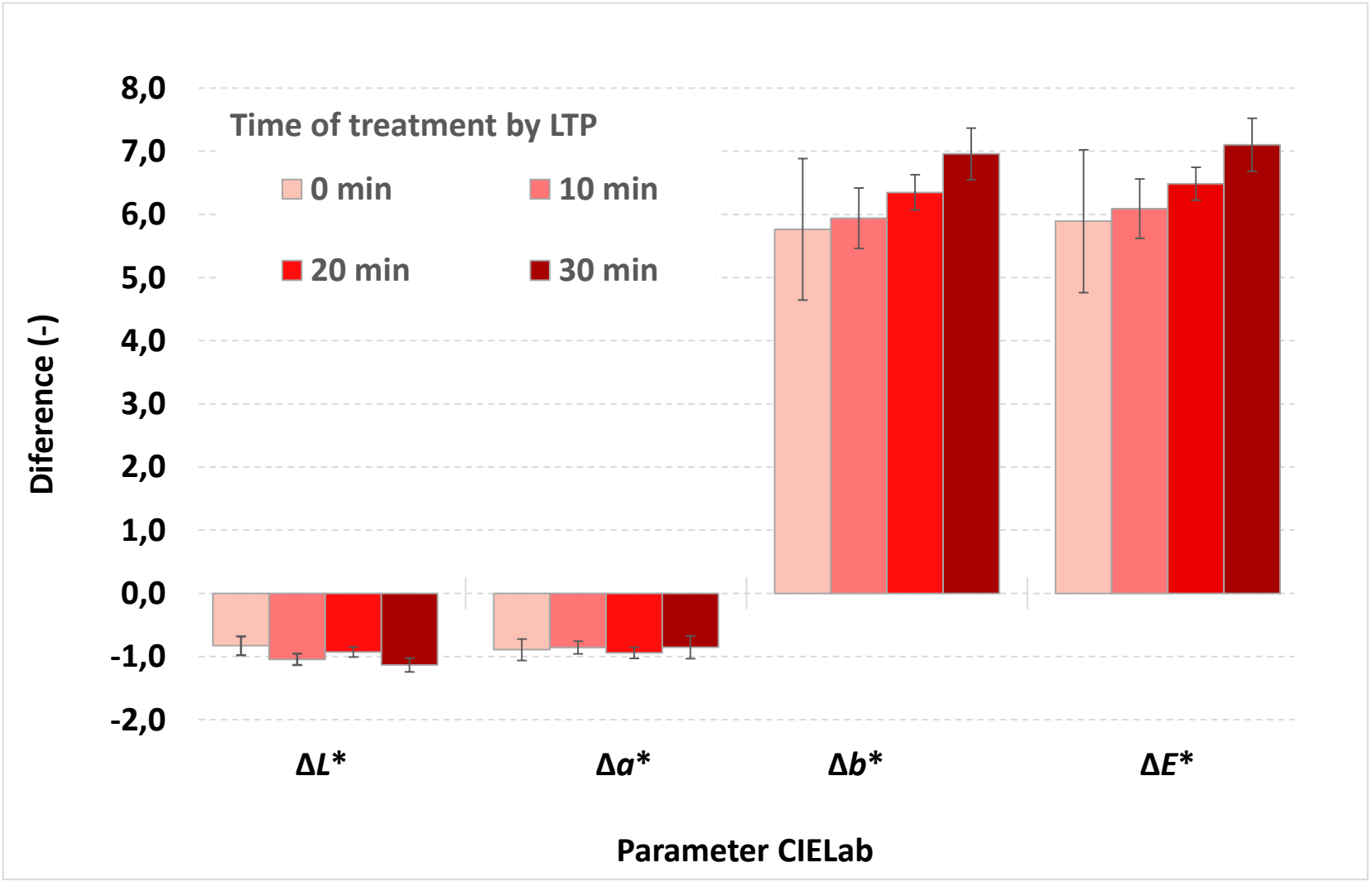
- **Chemical properties** (standard ISO 6588)
  Determination of pH of aqueous extracts

- **Viscometric determination of the average degree of polymerization in cupri-ethylene-diamine (CED) solution** (standard ISO 5351/1)

Results – Parameters CIELab after wet ageing

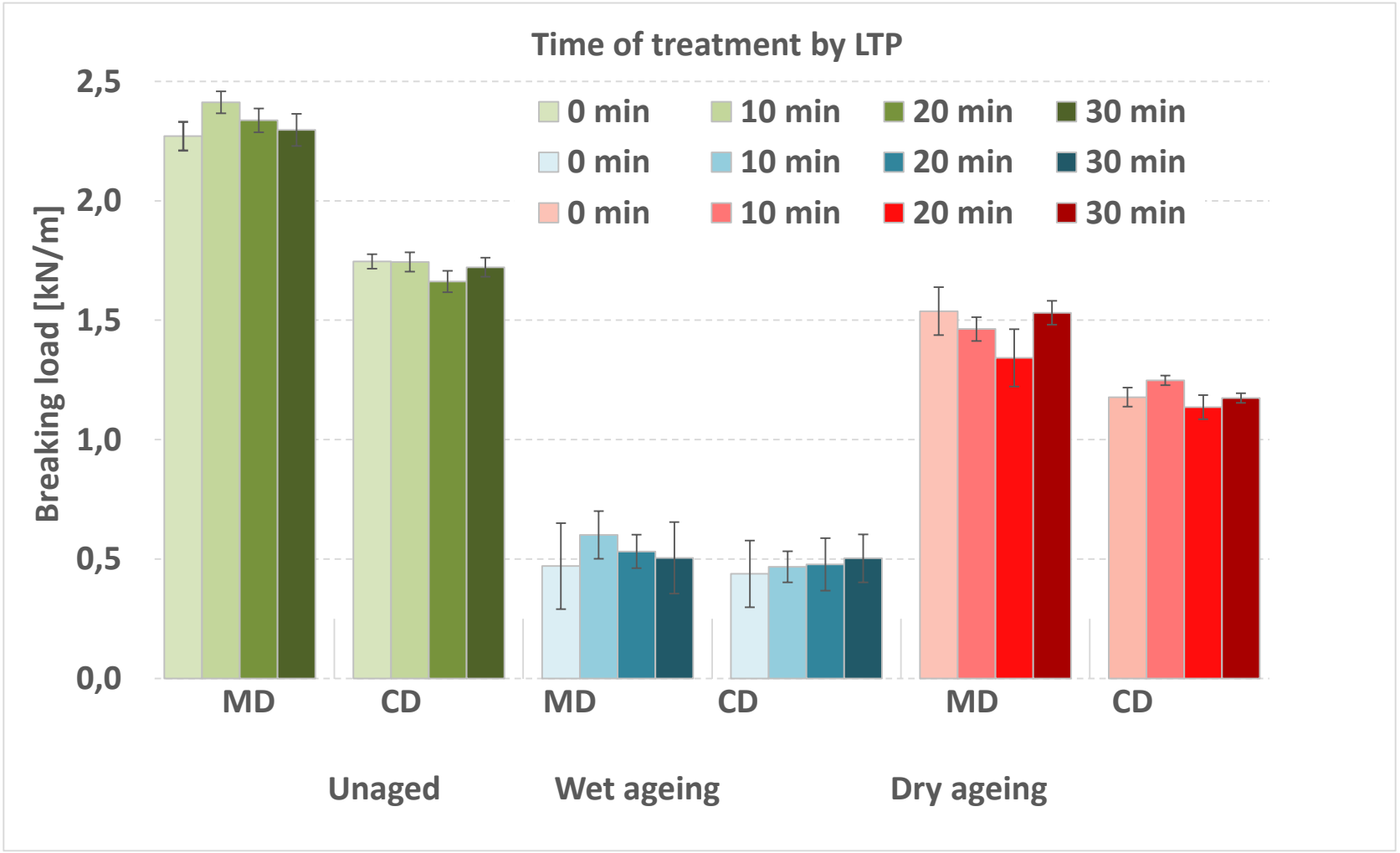


Results – Parameters CIELab after dry ageing



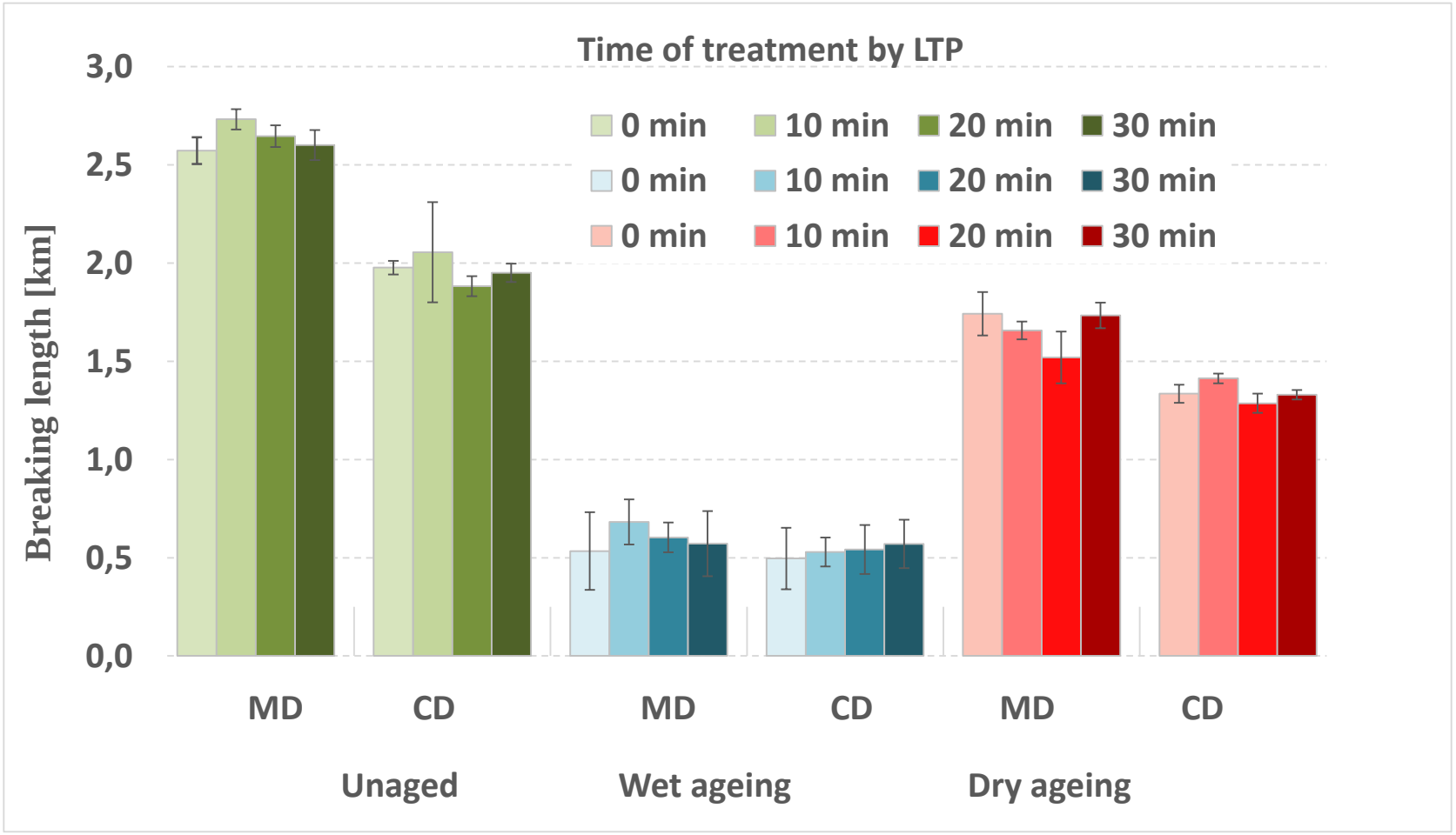
Results - Mechanical properties

Breaking load (kN/m)



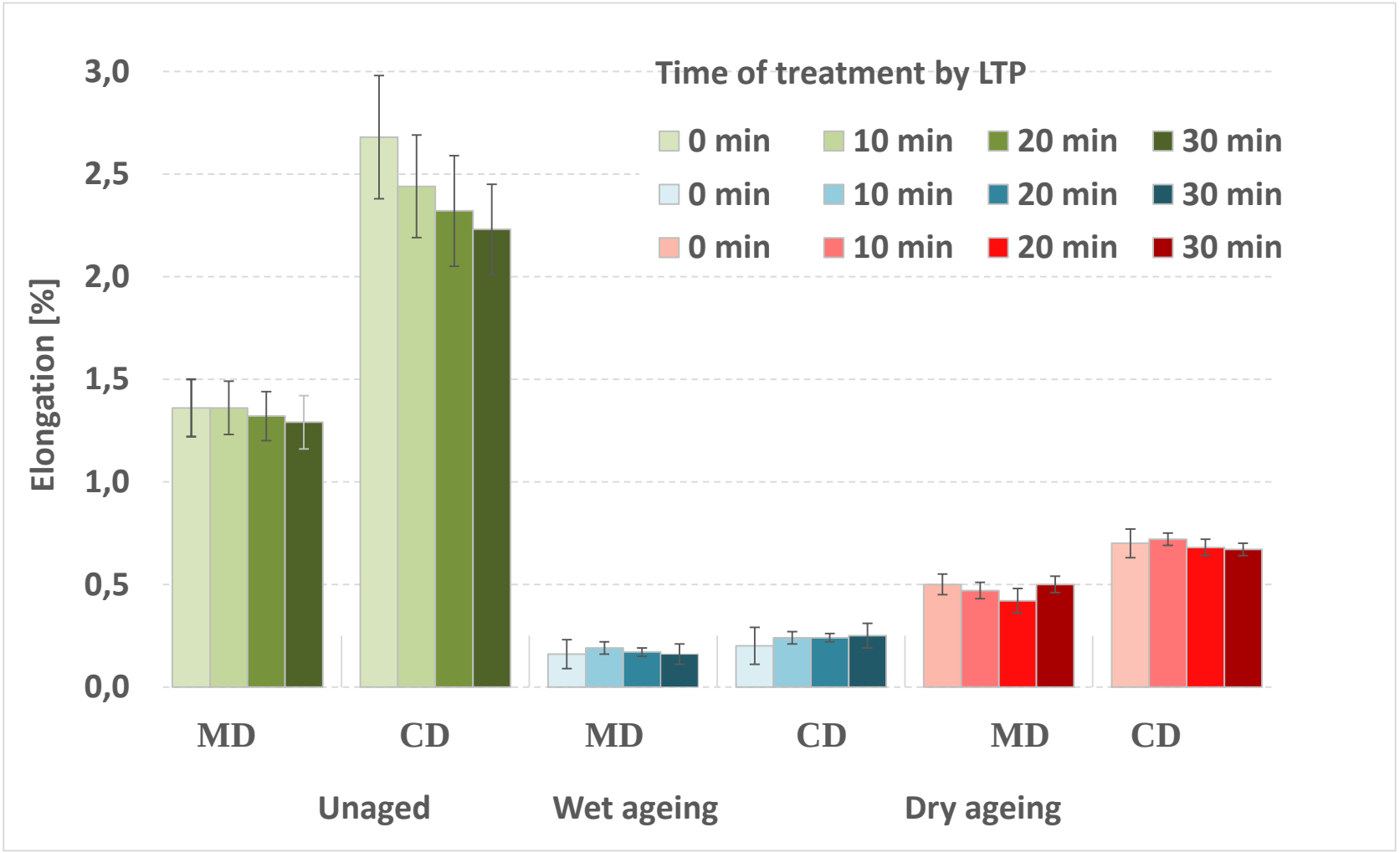
Results - Mechanical properties

Breaking length (km)



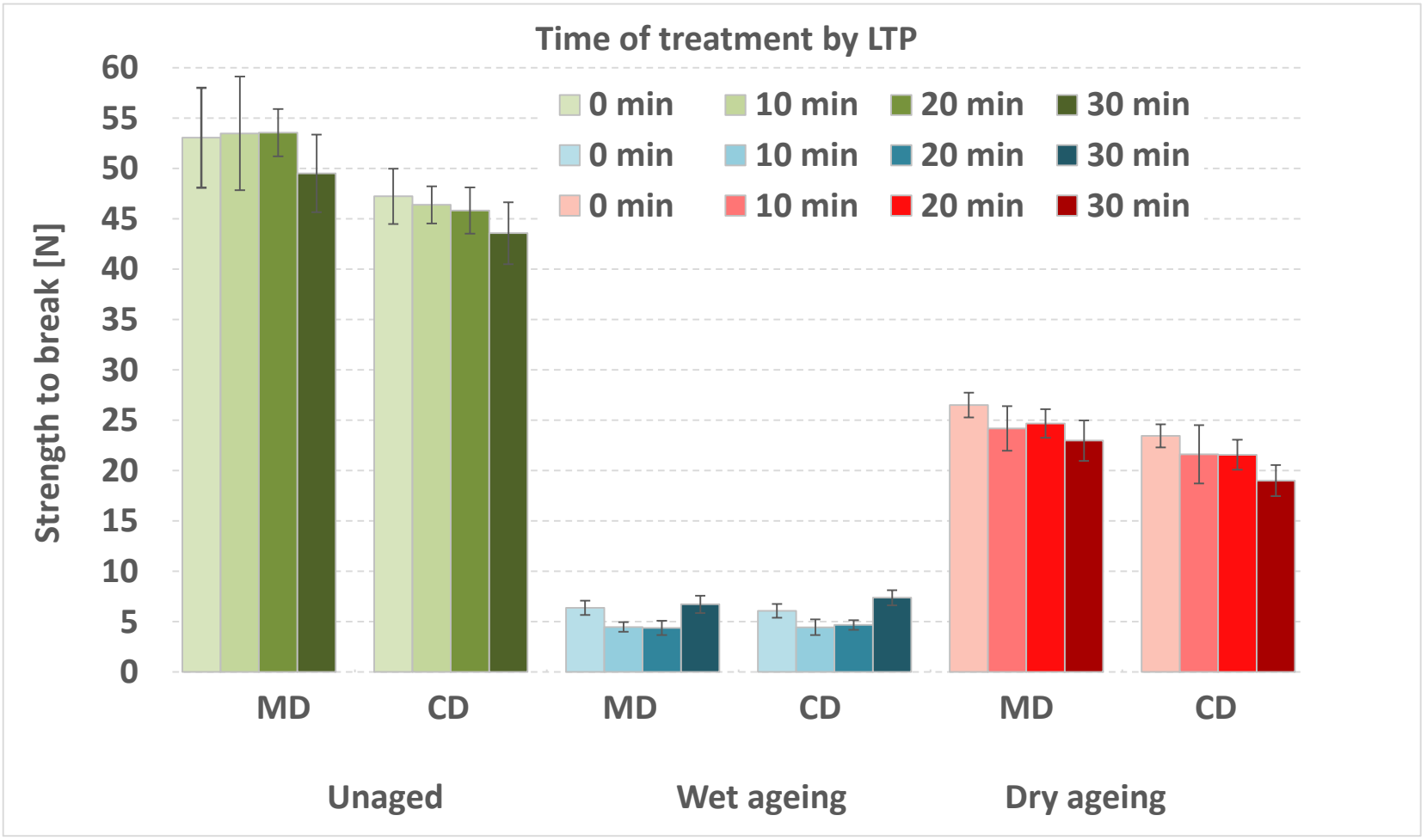
Results - Mechanical properties

Elongation (%)



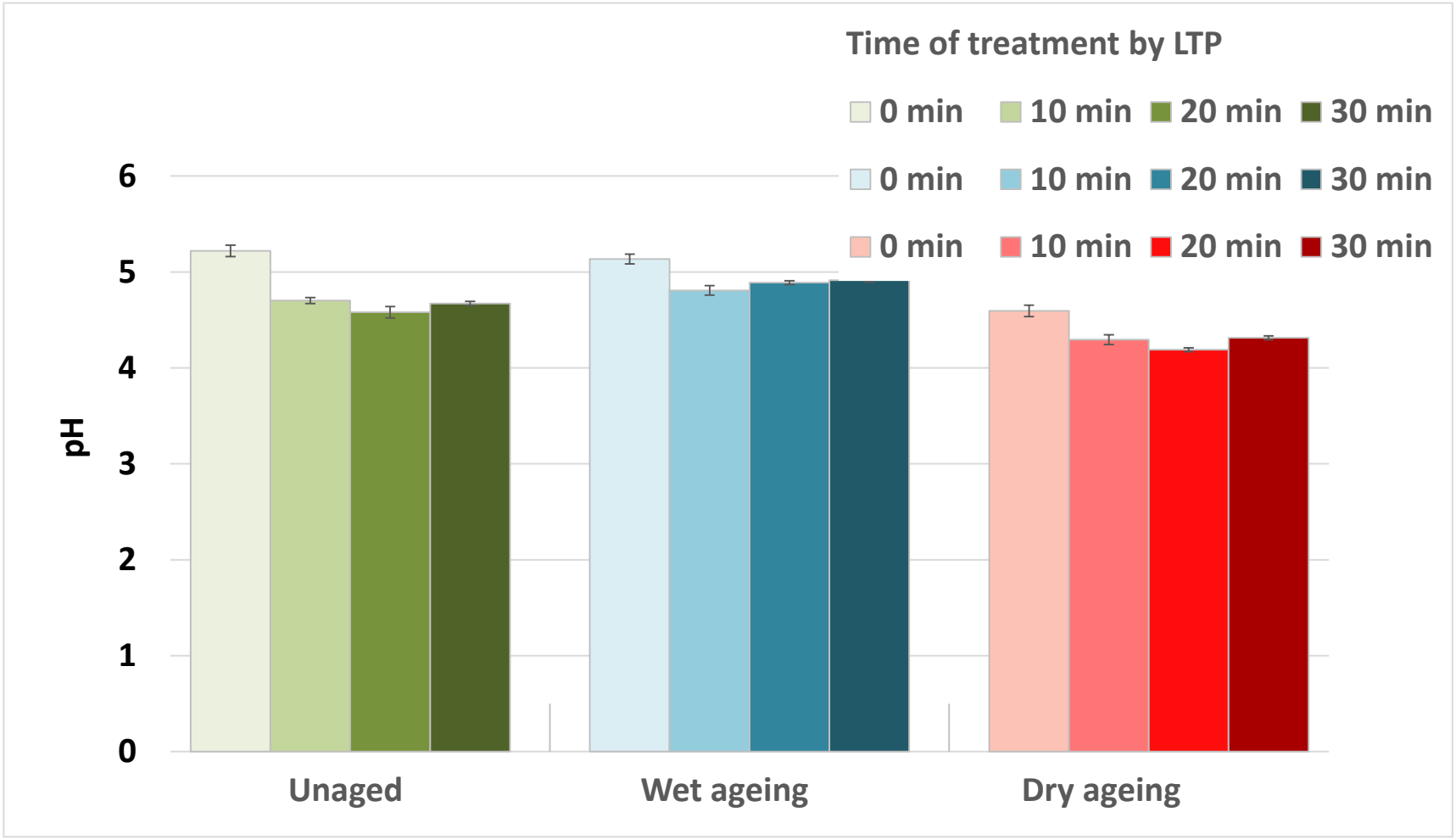
Results - Mechanical properties

Zero-span (N)



Results – Chemical properties

pH of aqueous extracts

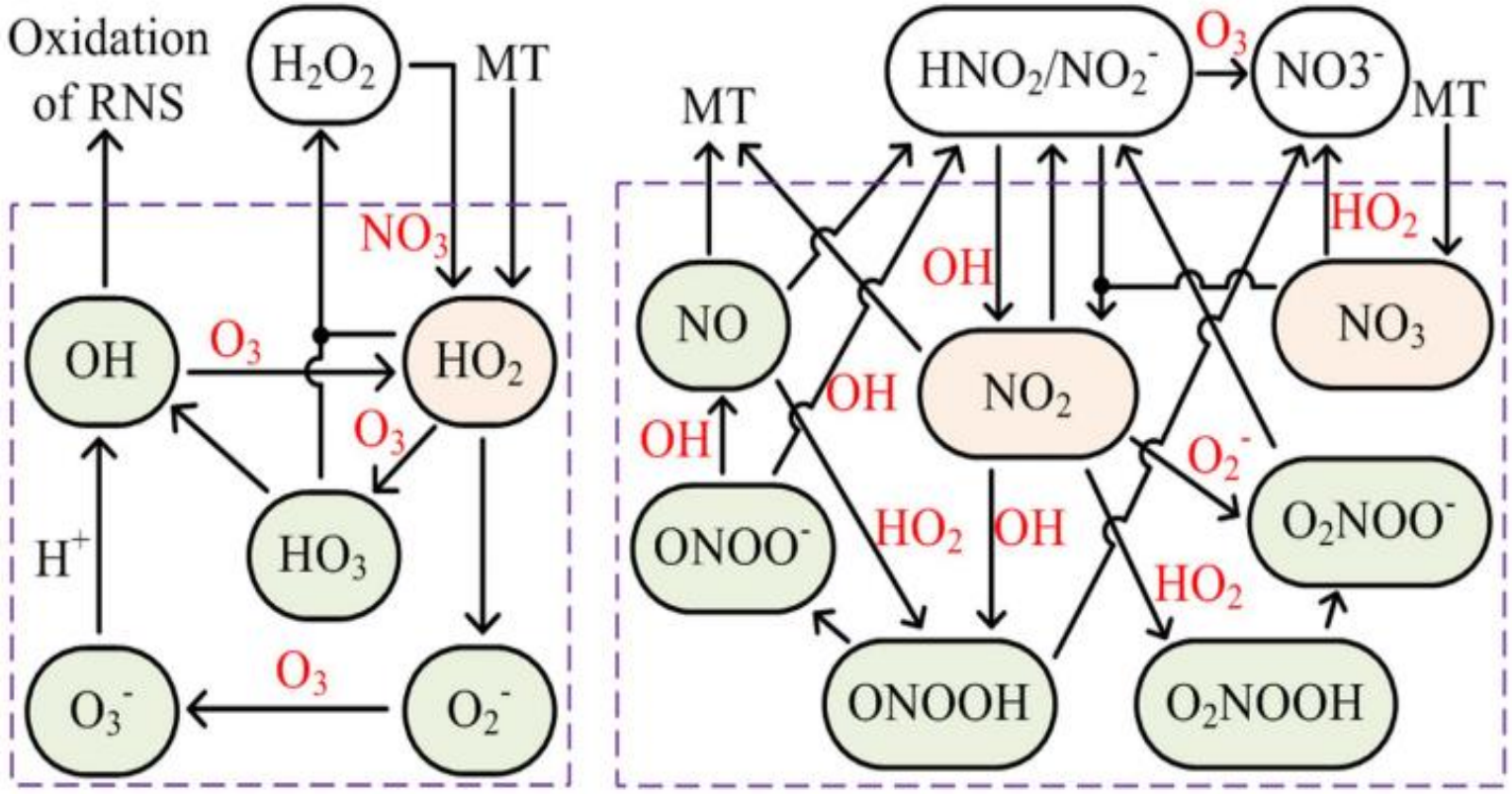


Results

Average degree of polymerization (DP)

Time for treatment by LTP (min)	DP	Δ (%)
0	2614	0,0
10	1668	- 36,2
20	1489	- 43,0
30	1479	- 43,4

Mechanisms of formation unstable compounds of nitrogen and oxygen in plasma



Conclusions

- 100% disinfection efficiency is achieved after longer time of treatment by low temperature plasma (30 minutes).
- Avarage degree of polymerization of cellulose after treatment by 30 minutes low temperature plasma tretament decreases about more than 40 % (!)
- The measurement of mechanical properties aren´t sufficiently sensitive for the evaluation of changes in the paper (especially at the beginning of its destruction).
- Continue research, but with a different kind of plasma (Ar, He and N_2).

Thank you for attentation