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Influence of Compression Treatment on Surface Free Energy of Poplar Wood Calculated by Different Methods

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Outline

- Background
- Experimental program and theoretical methods
- Results and discussion
- Conclusions
- Acknowledgement

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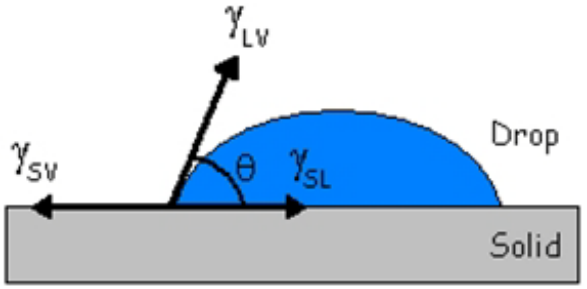
Background

- **Surface properties of wood**
  - depth of penetration
  - uniform distribution of adhesive
  - bonding quality
- **Surface free energy（SFE）**
  - critical surface tension method (**CST**)
  - geometric mean method (**GM**)
  - harmonic mean method (**HM**)
  - acid–base method (**AB**)
- **Our objective**
  - calculate the SFE of poplar wood
  - analyze the differences of compression treatment

Theories



Young equation

$$\gamma_L \cos\theta = \gamma_S - \gamma_{SL}$$

γ_L-surface tension of test liquid, γ_S -surface free energy of the solid
θ -contact angle, γ_{SL} -solid/liquid interfacial energy

1 Critical surface tension method (CST)

$$\gamma_C = \gamma_L + \frac{\cos\theta - 1}{b}$$

2 Geometric mean method (GM)

$$\gamma_L(1+\cos\theta) = 2(\sqrt{\gamma_S^d \gamma_L^d} + \sqrt{\gamma_S^p \gamma_L^p})$$

? ?

γ_S^d and γ_S^p is the dispersed and polar component of surface free energy of the solid

3 Harmonic mean method (HM)

$$\gamma_L(1+\cos\theta)=\frac{4\gamma_S^d\gamma_L^d}{\gamma_S^d+\gamma_L^d}+\frac{4\gamma_S^p\gamma_L^p}{\gamma_S^p+\gamma_L^p}$$

4 Acid–base method (AB)

$$\gamma_L(1+\cos\theta)=2\sqrt{\gamma_S^{LW}\gamma_L^{LW}}+2\sqrt{\gamma_S^+\gamma_L^-}+2\sqrt{\gamma_S^-\gamma_L^+}$$

? ? ?

γ_L^{LW} -Lifshitz–van der Waals component of test liquids

γ_L^- -electron–donor parameter

γ_L^+ -electron–acceptor parameter

Experimental program

Testing liquids

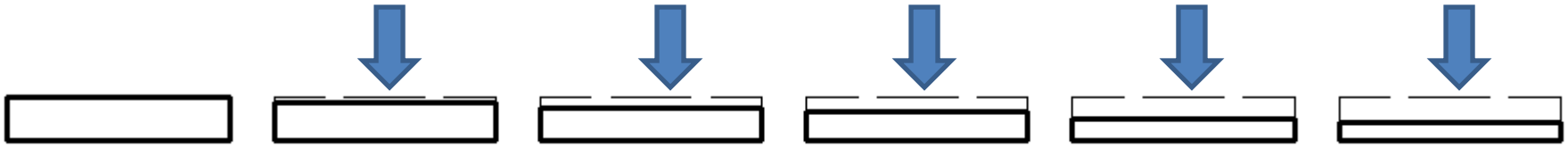
- Water
- n-Hexane
- Glycerol

Contact angle(θ) measurements

Wilhelmy plate method

KSV Sigma 701 Tensiometer

Preparation of specimens



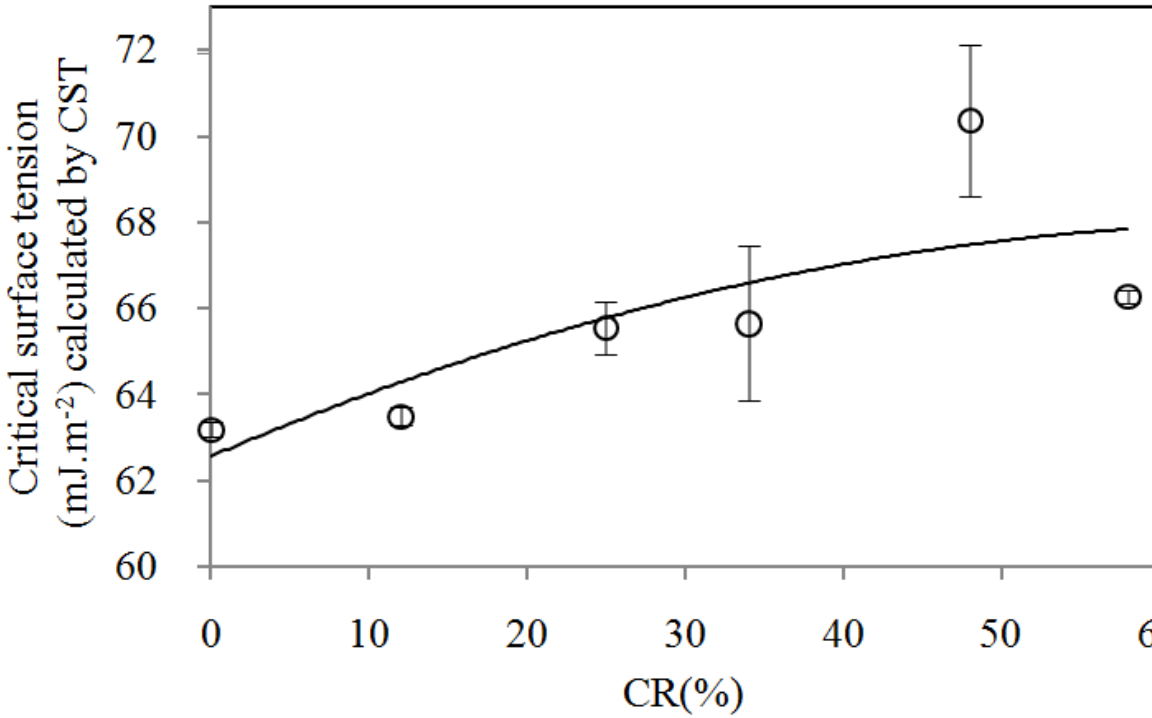
CR =0 CR =12% CR =25% CR =34% CR =48% CR =58%

normal wood compressed wood

Results and discussion

1. Critical surface tension method (CST）

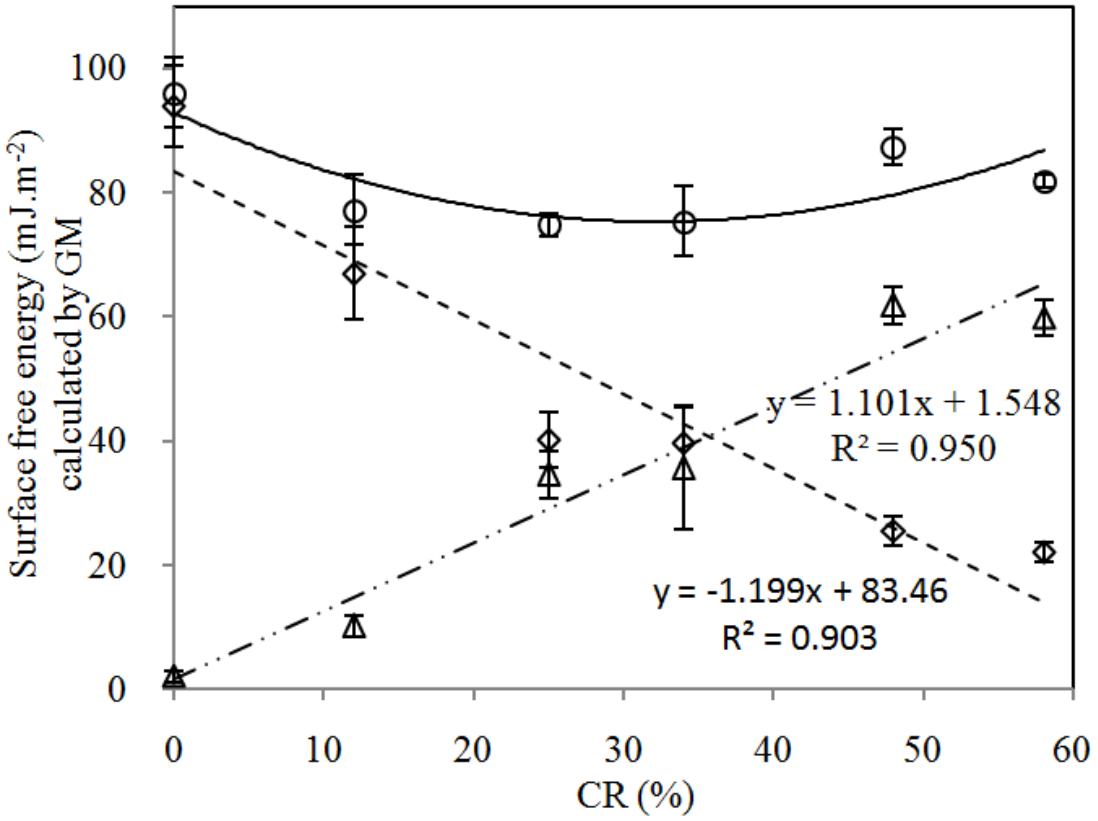
- γ_C increases slightly by increasing compression ratio （CR）



Critical surface tension of compressed popla wood with different CR

- The maximum value is 70.4mJ.m^{-2} at CR of 48%

2. Geometric mean method (GM)



Surface free energy of compressed poplar wood with different CR (GM approach)

○- total SFE (γ_S)

◇-dispersed component (γ_S^d)

△- polar component (γ_S^p)

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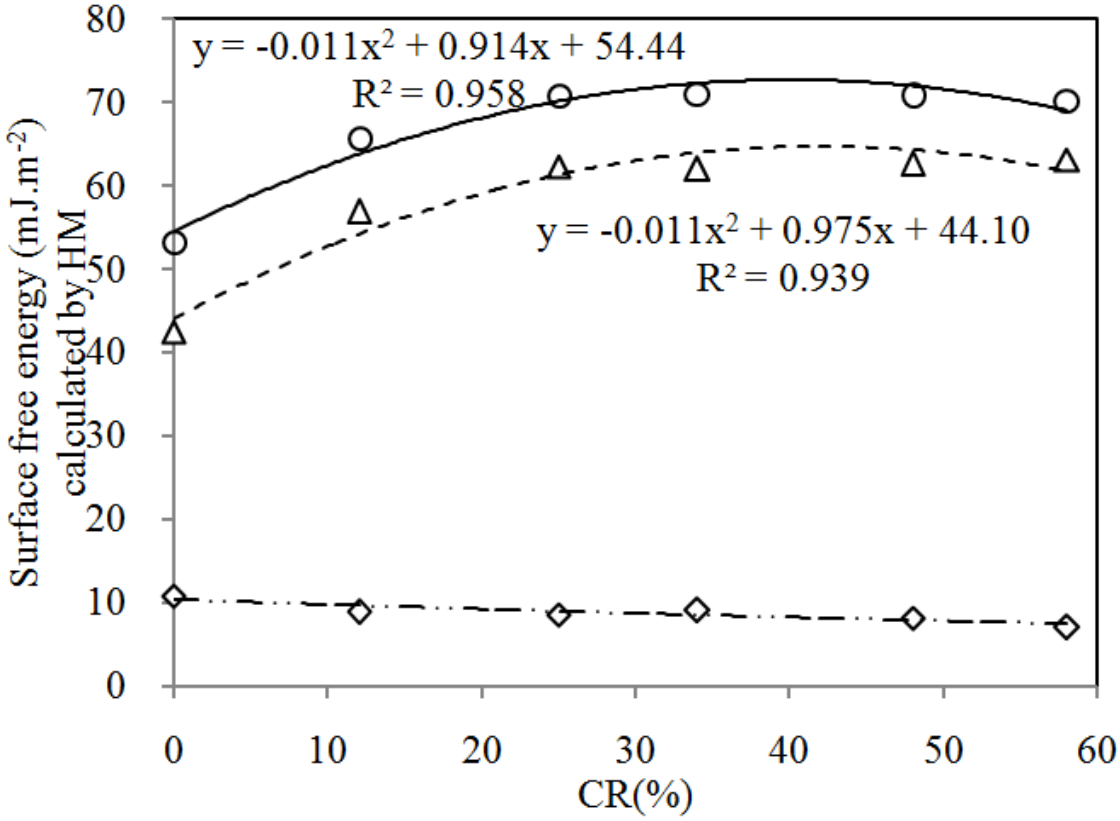
3. Harmonic mean method (HM)



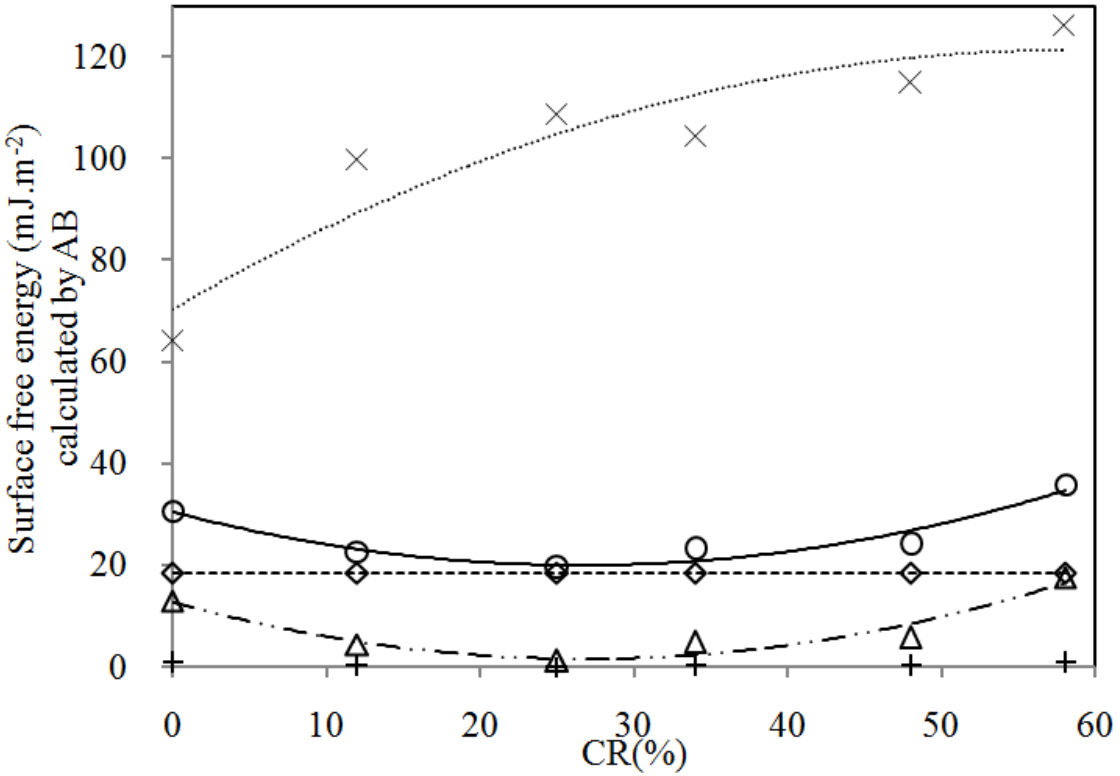
SFE of compressed wood with different CR (HM approach)

○- total SFE (γ_S)

◇-dispersed component (γ_S^d)

△- polar component (γ_S^p)

4. Acid–base method (AB)



SFE of compressed wood with different CR (AB approach)

$\gamma_S^{LW} = 18.4\ \text{mJ.m}^{-2}$

○- total SFE(γ_S)

◇- dispersed component (γ_S^{LW})

△- polar component (γ_S^{AB})

＋- electron–acceptor (γ_S^+)

×- electron–donor (γ_S^-)

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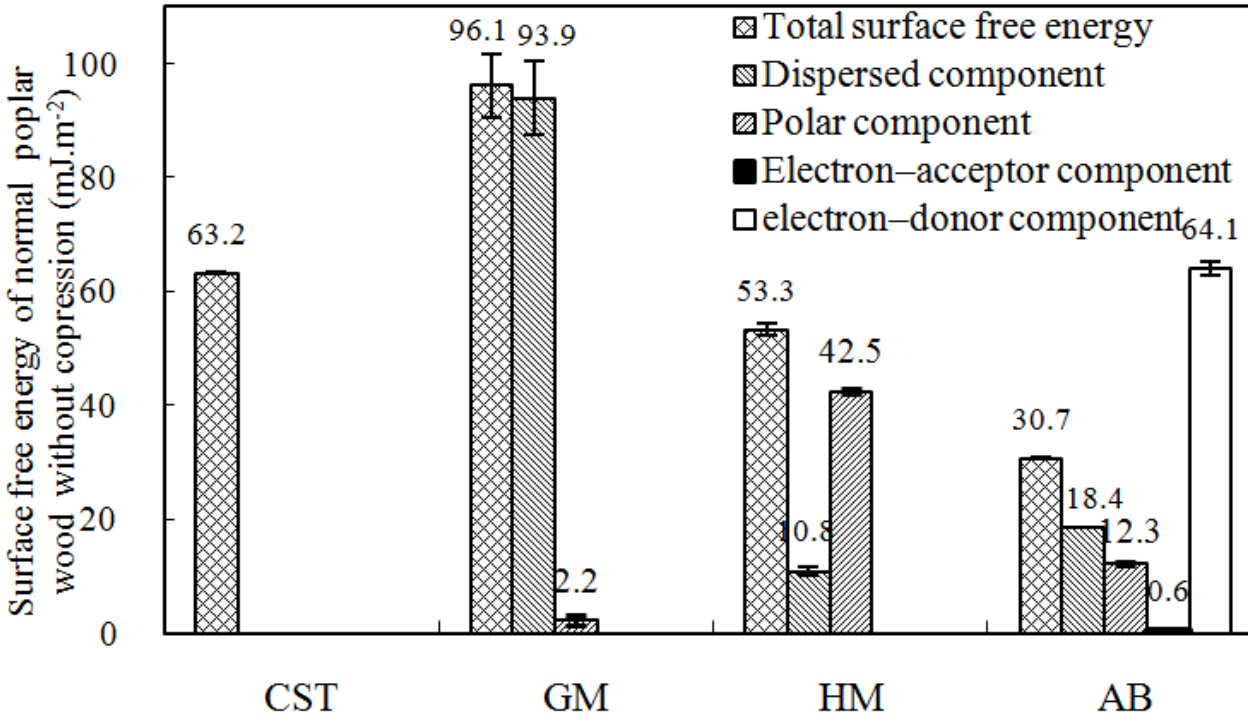
Comparison of different methods

The values of SFE(γ_s) of normal poplar wood

GM > CST > HM > AB



The values of SFE and components obtained with approaches of CST, GM, HM and AB.

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Conclusions

◆**The γ_C value of poplar wood increases slightly by increasing of CR.**

◆ **GM approach gives the highest value(96.1 mJ.m^{-2}) of SFE compared to other approaches.**

◆ **The γ_S^{LW} keep unchanged at 18.4 mJ.m^{-2} with the poplar wood compressed or not**

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Thank You !