Polymerization kinetics of composites with copper-doped mesoporous bioactive glass nanospheres

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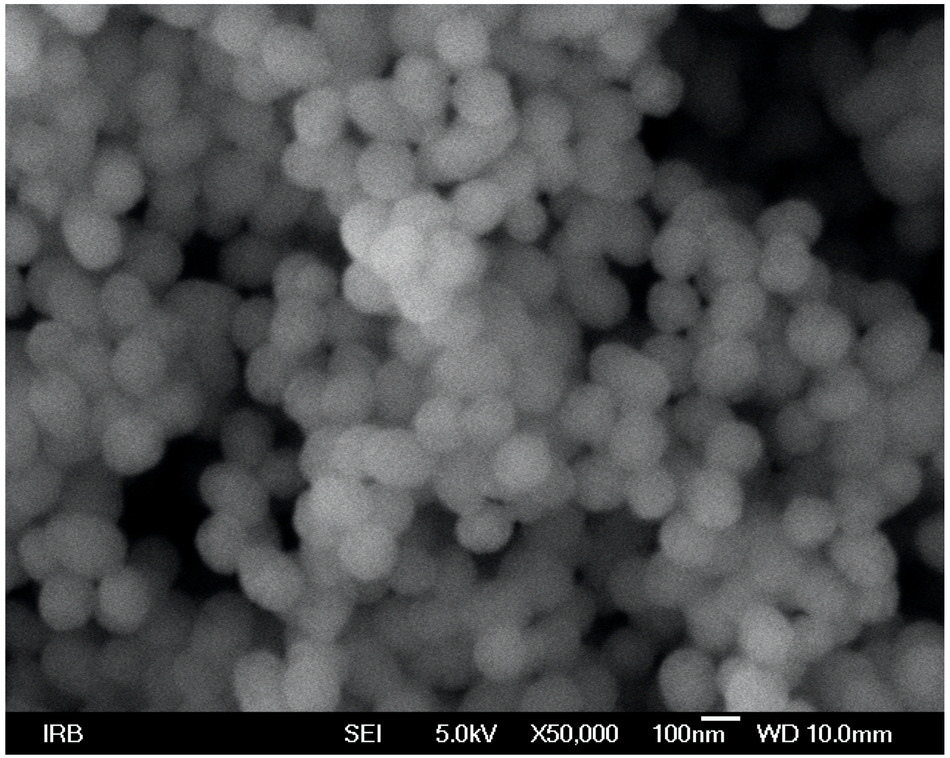
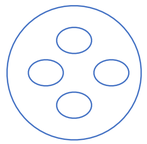
Copper-doped mesoporous bioactive glass nanospheres (Cu-MBGN)



- Bioactive glass
  - release of Ca and PO_4
  - remineralization
- Mesoporosity - entanglement of polymer network
- Copper - antibacterial properties



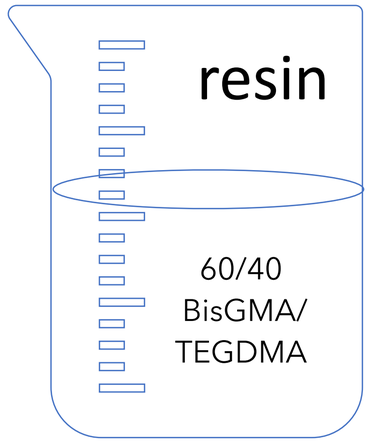
Marovic D et al. 2021 https://www.mdpi.com/1112512

Aim

To investigate the effect of Cu-MBGN addition to dental composite resins on the:

- polymerization kinetics and
- short-time degree of conversion (DC).

Materials and Methods



+

photoinitiator system

+

fillers

Cu-MBGN

Inert Ba-glass

Inert nano-silica

45S5 bioactive glass

composite resins

Types of fillers

Name	Type	Manufacturer/ Product	Composition (wt %)	Size	Silanization
Cu-MBGN	Experimental/ Bioactive	Laboratory made	SiO_2 84.8% CaO 9.4% CuO 5.8% *	~100 nm	No
45S5 bioactive glass	Commercial/ Bioactive	Schott, Germany G018-144	SiO_2 45% Na_2O 24.5% CaO 24.5% P_2O_5 6%	4.0 µm	No
Ba-glass	Commercial/ Inert	Schott, Germany GM27884	SiO_2 55.0% BaO 25.0% B_2O_3 10.0% Al_2O_3 10.0%	1.0 µm	Yes 3.2%
Silica	Commercial/ Inert	Evonik Degussa, Germany Aerosil DT	SiO_2 > 99.8%	12 nm	Yes 4–6%

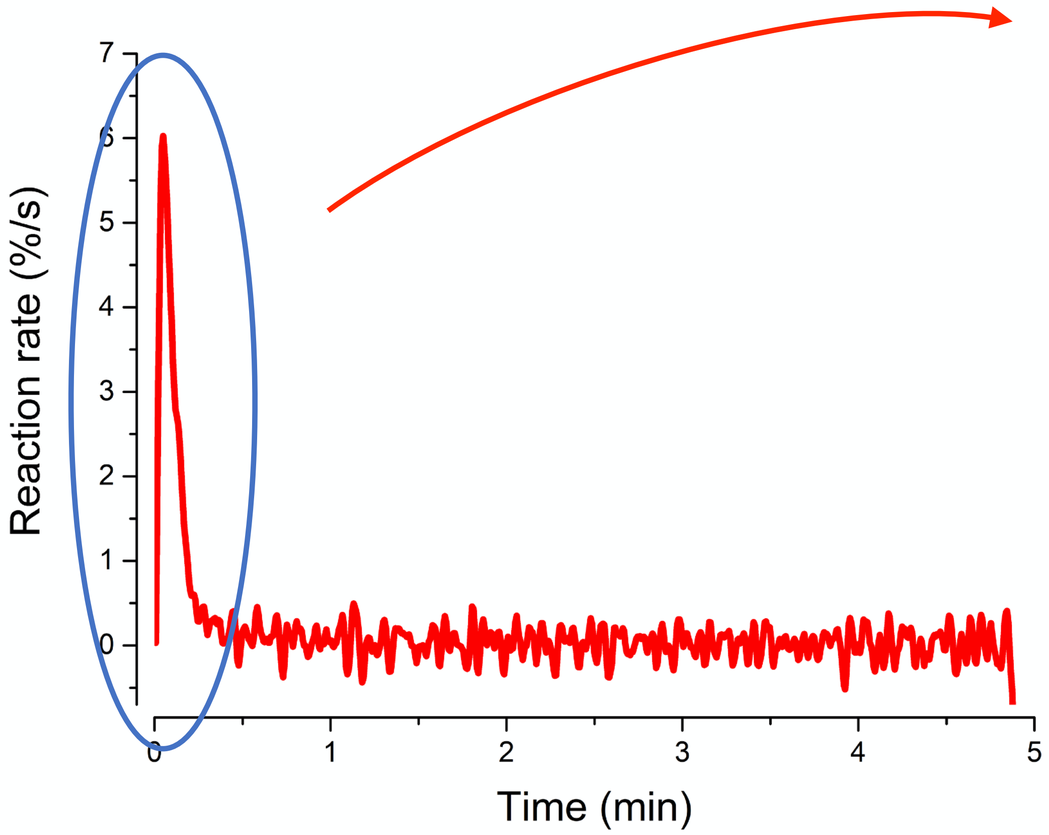
Composition of experimental composite resins

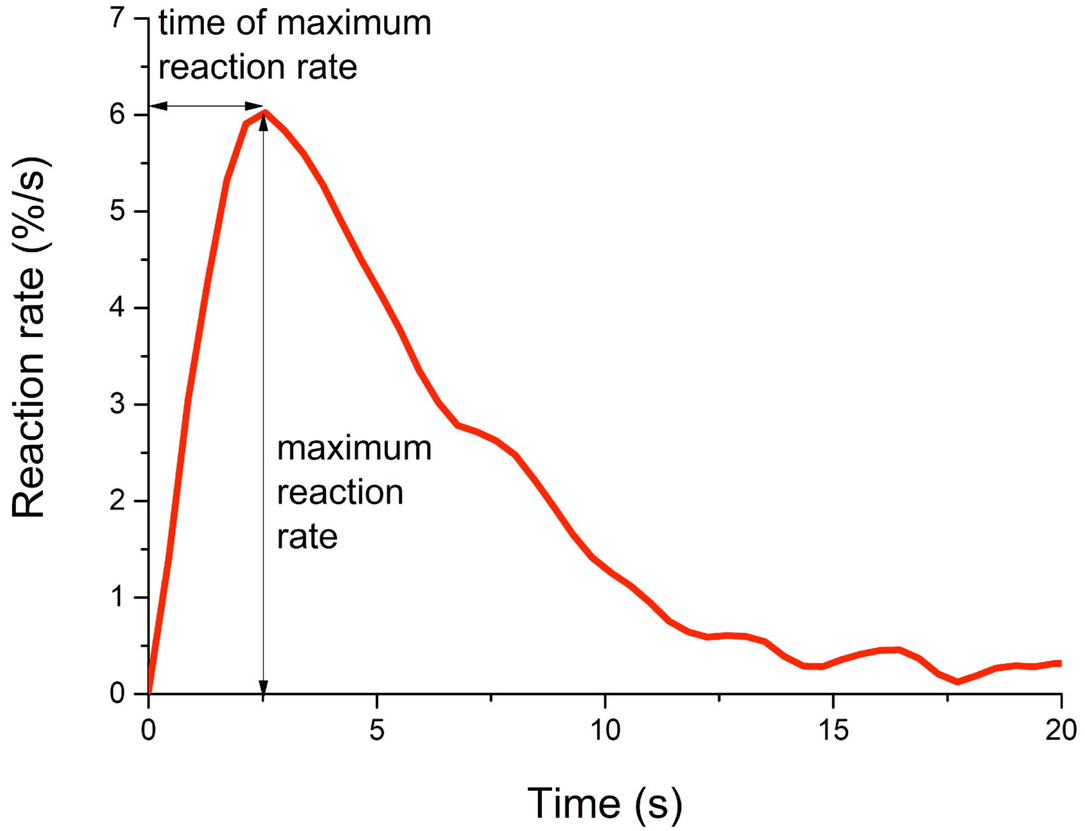
	Material	Resin	Inert Ba-glass microfillers	Silica nanofillers	Cu-MBGN	45S5 BG
Bimodal approach	10-CuBG	35 %	55 %	-	10 %	-
	10-BG			-	-	10 %
	10-Si			10 %	-	-
Trimodal approach	1-CuBG-Si		51 %	13 %	1 %	-
	5-CuBG-Si			9 %	5 %	-
	14-BG			-	-	14 %
	14-Si			14 %	-	-

TOTAL filler load - 65%

Measurement of degree of conversion (DC)

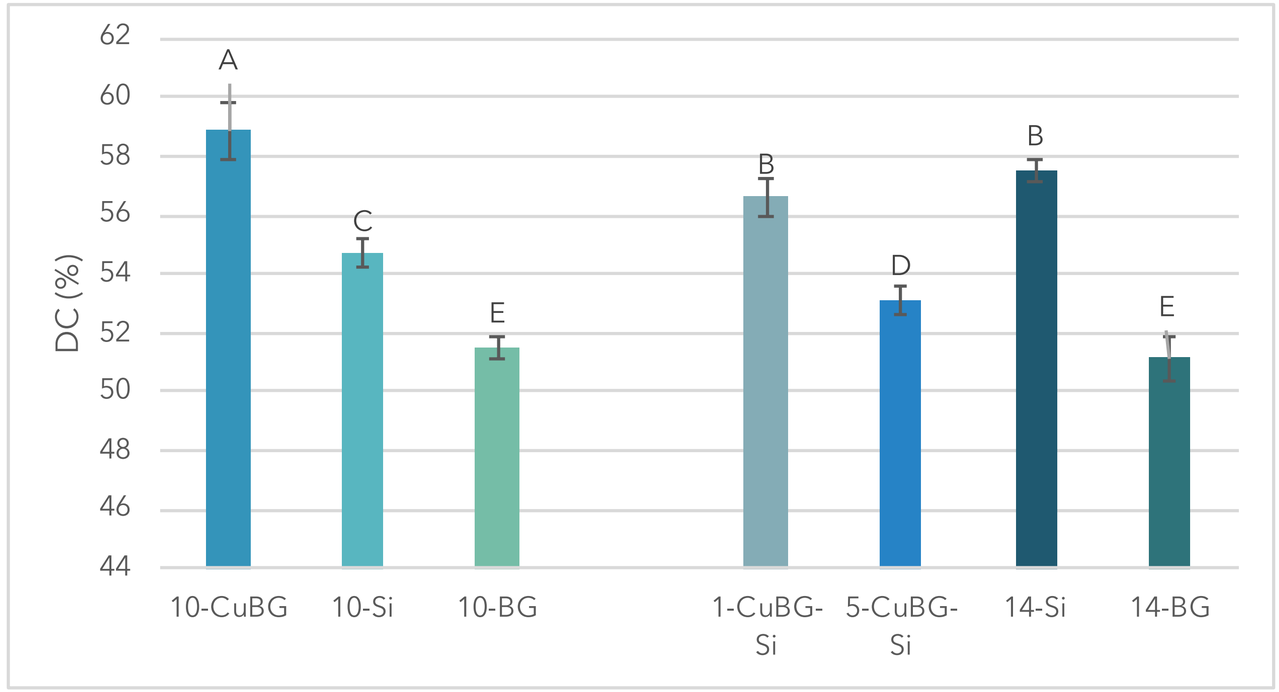
- specimens (n=5) were light-cured for 20 s with 950 mW/cm^2
- attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR)
- real-time measurement - 5 min
- data collection rate - 2 s^{-1}.
- Parameters: DC, maximum reaction rate, and time of maximum reaction rate
- Statistics: ANOVA and Tukey post-hoc test ($p<0.05$).

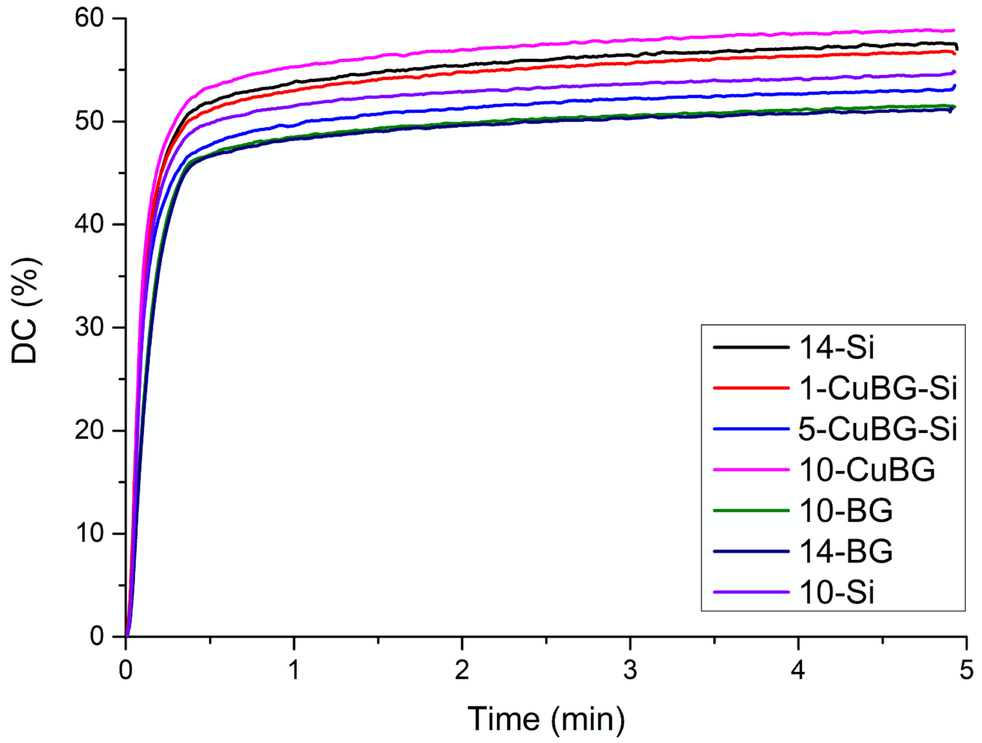

Reaction rate (%/s)
Time (min)
0
1
2
3
4
5
6
7


time of maximum
reaction rate
maximum
reaction
rate
Reaction rate (%/s)
Time (s)
0
5
10
15
20

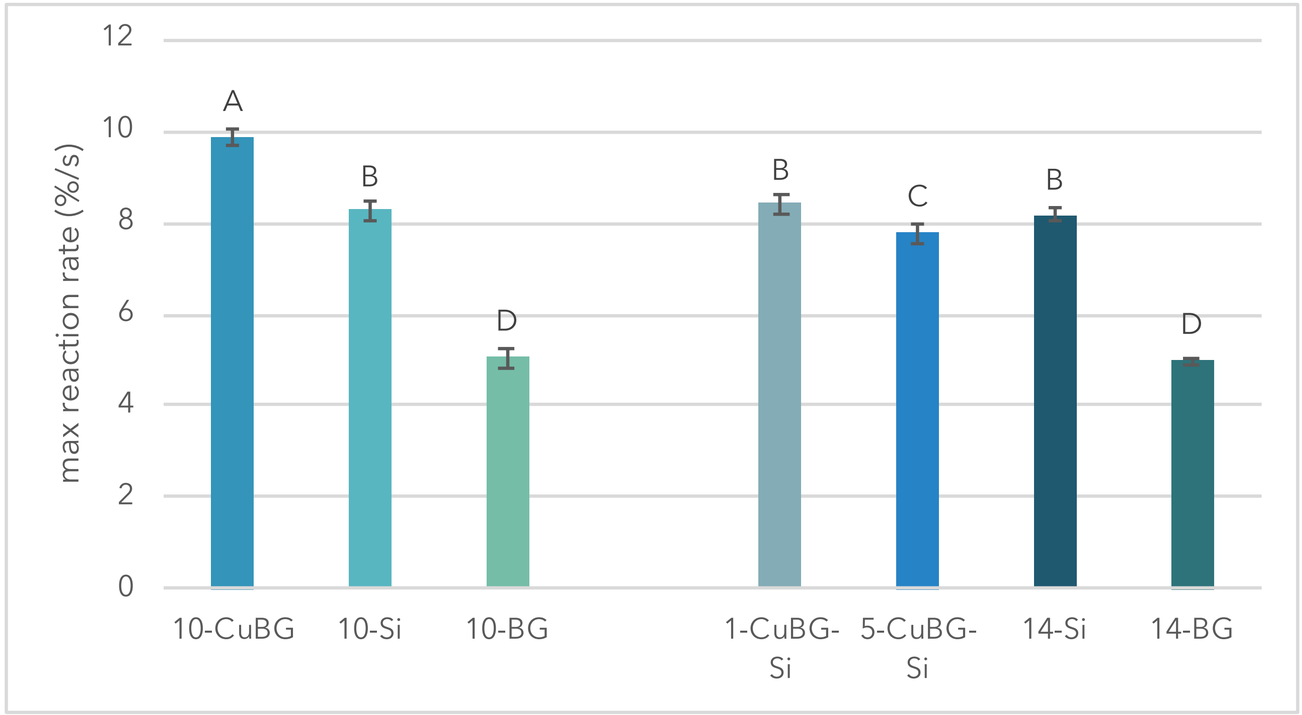
Results

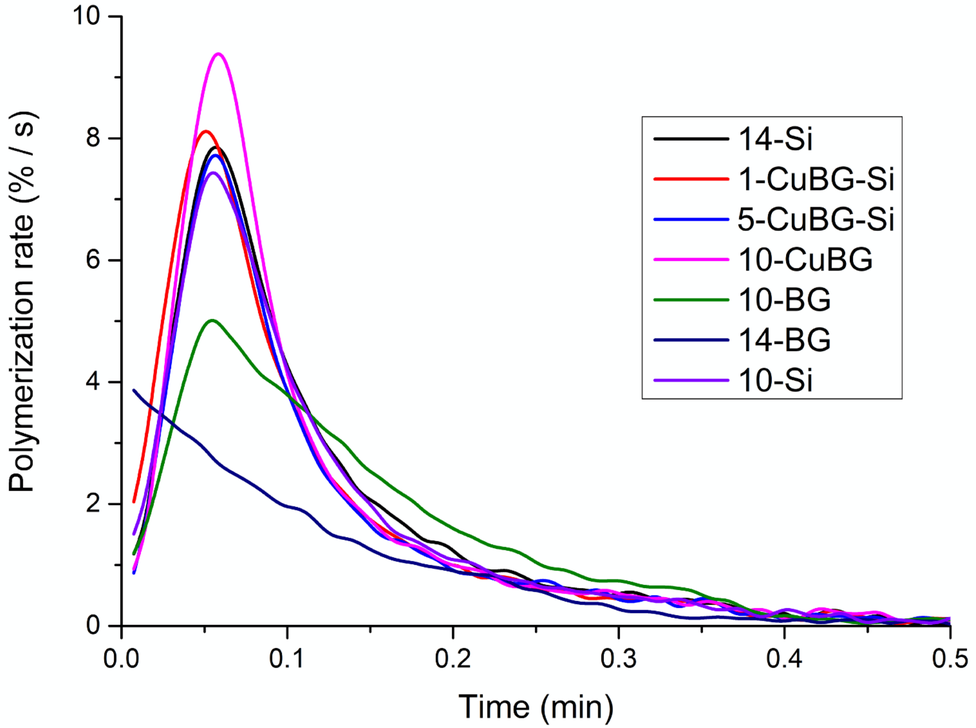
Degree of conversion



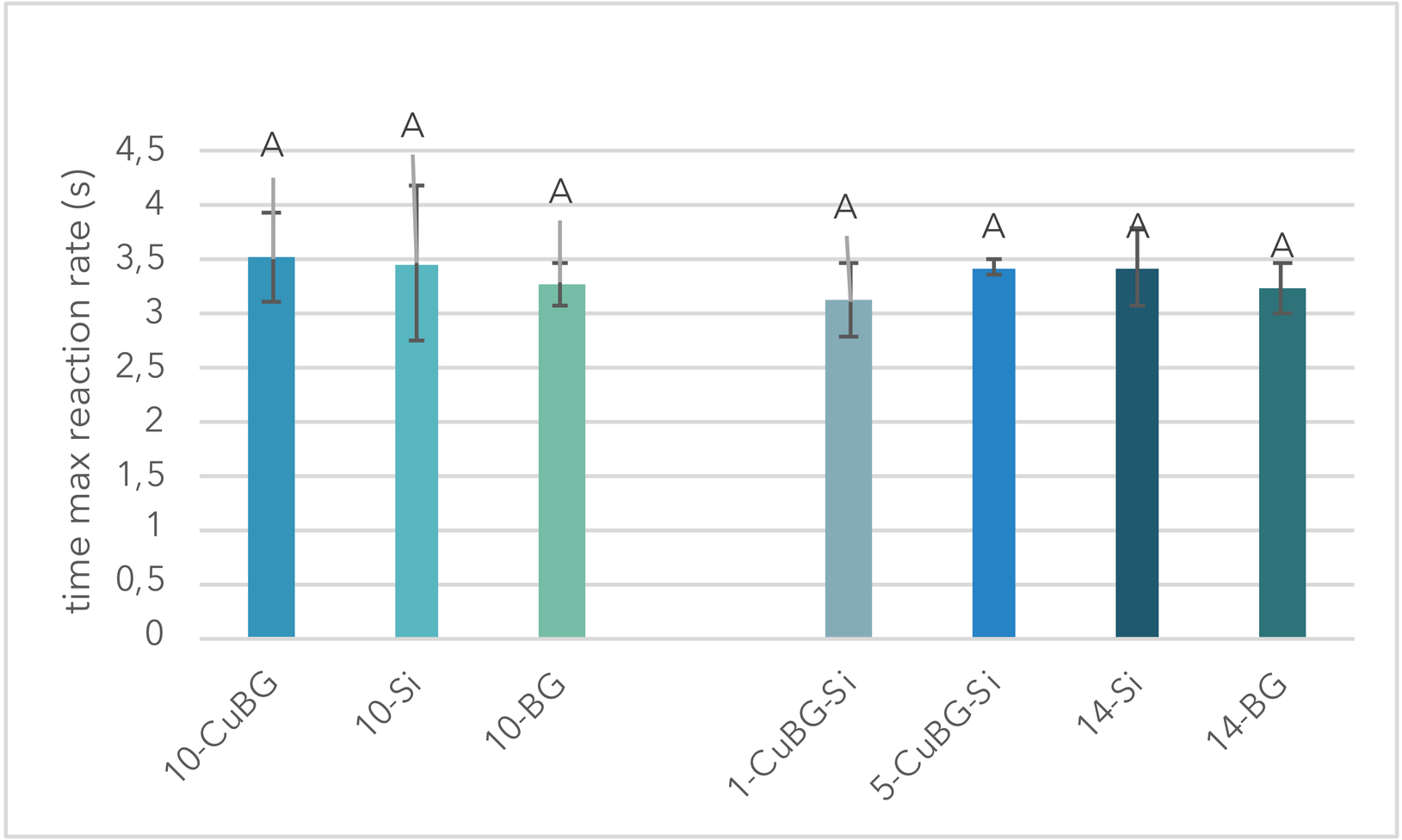


Maximum reaction rate (%/s)





Time to achieve maximum reaction rate



Results

10-CuBG - the highest DC (58.8±0.9%), as well as the maximum reaction rate (9.8±0.2 %/s)

14-BG (and 10-BG) - the lowest DC (51.1±0.7%) and the lowest maximum reaction rate (5±0.1 %/s)

An increasing amount of CuMBGN in combination with silica fillers caused a mild inhibitory effect.

There was no difference in the time to achieve maximum reaction rate between any of the tested materials (3.1-3.4 s).

Conclusion

Resin composites with 45S5 bioactive glass showed the most substantial inhibitory effect on polymerization kinetics, while copper-doped mesoporous bioactive glass nanospheres showed a mild inhibitory effect.

The authors declare no conflict of interest.

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