

Light Curing in Dentistry, Dalhousie University, Halifax, May 28-30, 2014

## Influence of exposure time on the depth of cure

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## Nordic Institute of Dental Materials

- Independent research and test institute
- Established in 1972, located in Oslo, Norway
- Research, testing, standardization, and information
  - Mechanical testing / Physical properties
  - Chemical analysis
  - Biological testing and evaluation
  - Clinical research



*Ensure the use of safe and well-functioning dental materials  
for the patients in the Nordic countries*



## Laboratory facilities

- Material characterization (FT-IR, TMA)
- Universal testing machines (2.5, 10 kN)
- Dynamic mechanical testing (3 kN)
- Analytical instruments (GC/MS and LC/MS)
- Light source measurement (spectrometer-based, integrating sphere)
- Microscopy
- Cell- and bacterial laboratory (flow cytometer, PCR, micro-plate reader)
- Sample preparation (casting machines, firing furnaces, micro-cutter, speed-mixer, polymerization techniques, grinding and polishing)



## Curing recommendations

### Composite manufacturers

- Typical layer depth:
  - 2 - 2.5 mm
  - Reduced if opaque or dark
- Typical light out-put:
  - > 500 or 700 mW/cm<sup>2</sup>
- Typical curing time:
  - 20 s
  - 40 s for opaque or dark
  - Shorter time for higher out-put (ex. 10 sec. > 1100 mW/cm<sup>2</sup>)

### Curing light manufacturers

- “due to the light intensity of 1,600 mW/cm<sup>2</sup>, the curing times are reduced to **10 seconds** for all composites “
- “it takes only **6 to 12 seconds** to polymerize a 2 to 3mm thickness of any composite“
- “a true **5-second** cure without overheating intrapulpal temperature or the unit itself“
- “the worlds most powerful curing light ... cures any composite in **1-3 seconds** per layer“



## Match or mismatch between curing recommendations?

- Curing light manufacturers: 1 - 20 seconds
- Composite manufacturers: 10 - 40 seconds
- Dental schools:
  - 20 - 40 s, University of Oslo, University of Bergen
  - ?? Dalhousie
  - USA?
  - Europe?
  - ...?

What does the general dentist do?



## Investigation of «short» and «long» curing times

Short: as recommended by the curing light manufacturer  
Long: as recommended by the composite material manufacturer

Table 2 - Curing devices and curing methods used in the study.

Curing device, manufacturer	Type	Light emitter, w/tip diameter	Curing time (s)	Acronym
bhaephase 16L Ivoclar Vivradent	LED	8 mm Power Booster <sup>a</sup>	5 <sup>a</sup> 10 <sup>b</sup> 20	BP-5 BP-10 BP-20
L.E Demetron II, Kerr	LED	8 mm Turbo tip <sup>b</sup>	5 20	DI-5 DI-20
Mini L.E.D., Satelec	LED	7.5 mm <sup>c</sup>	10 20	Mini-10 Mini-20
VCL 400, Kerr	QTH	11 mm (straight) <sup>d</sup>	20	VCL-20

<sup>a</sup> High power, i.e. constant maximum power (1600 mW/cm<sup>2</sup>).

<sup>b</sup> PLS (periodic level shifting) (800-1400 mW/cm<sup>2</sup>).

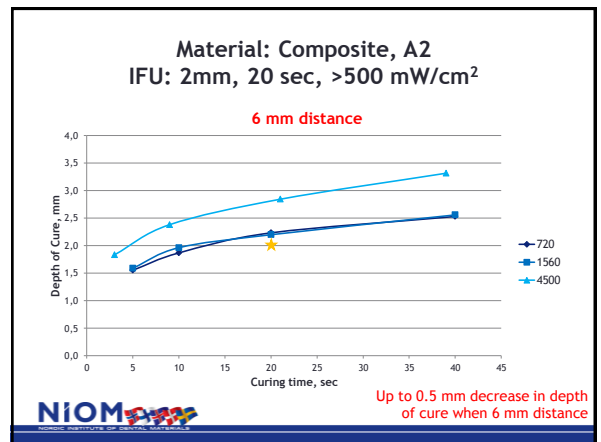
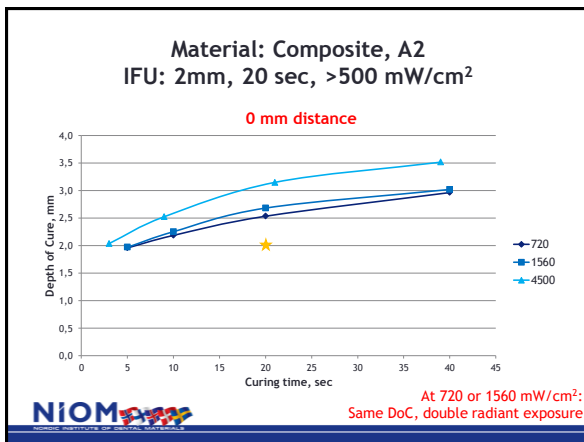
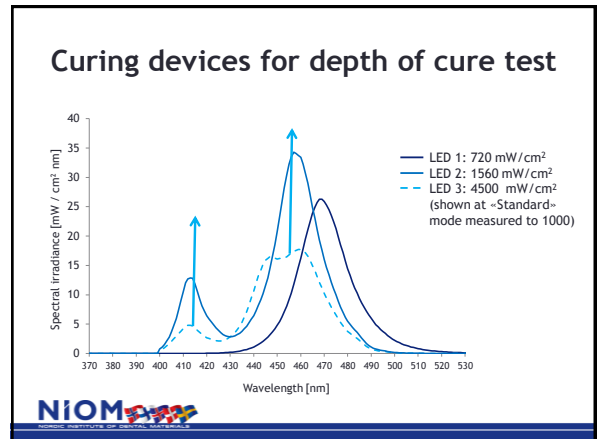
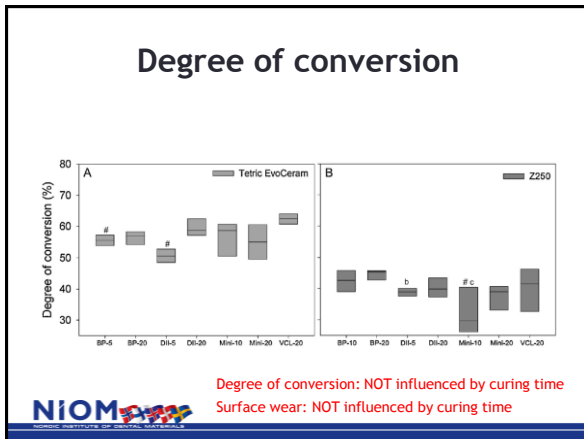
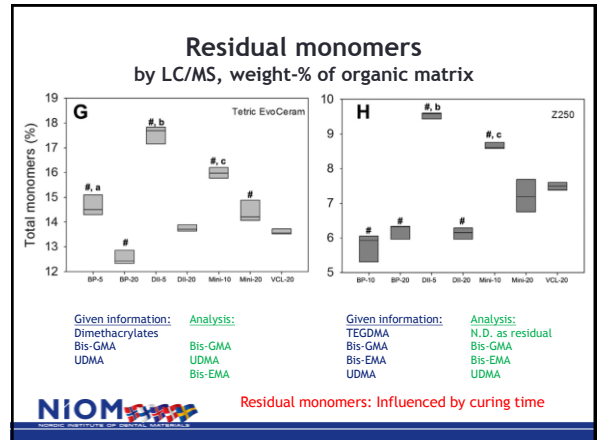
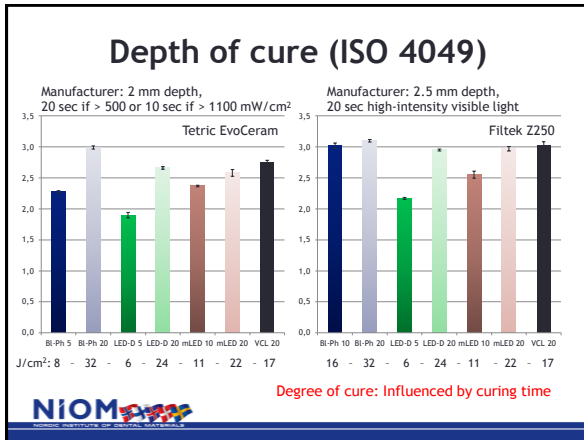
<sup>c</sup> Fast curing mode, i.e. constant maximum power (1100 mW/cm<sup>2</sup>).

<sup>d</sup> Intensity > 500 mW/cm<sup>2</sup>.

<sup>e</sup> Tetric EvoCeram: 5 s, Filtek Z250: 10 s.



Kopperud et al. Dent Mater 2013;29:824-34



## Effect of distance to curing tip: Total elution, 24h, 37°C, 75% ethanol

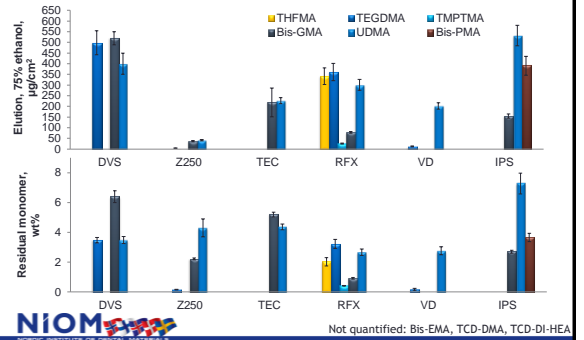
	$\mu\text{g}/\text{cm}^2$
Bulk Fill 1 (0 mm)	951
Bulk Fill 1 (6 mm)	1180
Bulk Fill 2 (0 mm)	598
Bulk Fill 2 (6 mm)	637
Bulk Fill 3 (0 mm)	1844
Bulk Fill 3 (6 mm)	3872
Bulk Fill 4 (0 mm)	523
Bulk Fill 4 (6 mm)	1028
Bulk Fill 5 (0 mm)	902
Bulk Fill 5 (6 mm)	1343

7 to 110 % increase in eluted monomers when increasing distance from light curing tip from 0 to 6 mm

Similar trend in water, but about 5% elution compared to in ethanol (24h only)



## Residual monomers vs elution in 75% ethanol



## Some correlations

- Depth of cure increases with increasing curing time
- Total residual monomer decreases with increase in depth of cure
- Residual monomer correlates with elution in 75% ethanol
- Elution in 75% ethanol increases with increasing distance to light tip

Decreased curing time or increased distance from light tip will reduce the depth of cure and increase the risk of monomer elution

