Development of an Early Warning Dosimeter for Organic Museum Objects

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Content

- Background
- The dosimeter working principle
- End user requirements
- Presenting a portable prototype - demonstration

Background - MASTER

- The EC funded MASTER project: ”Preventive Conservation Strategies for Protection of Organic Objects in Museums, Historic Buildings and Archives”
- 3 year project (2003 –2006)
- Two dosimeter prototypes were developed (EWO-G and EWO-S)
- Close cooperation with end-users
- An refined preventive conservation strategy for organic objects was developed

MASTER Participants

Research institutions:

- Norwegian Institute for Air Research (NILU), NO
- Centre for Sustainable Heritage (UCL), UK
- Albert Ludwigs University Freiburg (ALU-FMF), DE
- Technical University of Crete (TUC), GR

Museum partners and subcontractors:

- National Museum in Krakow, PO
- Trøndelag Folk Museum, NO
- Historic Royal Palaces, UK
- The National Trust, UK
- Württembergisches Landesmuseum, DE
- Wignacourt Collegiate Museum, Rabat, ML

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Background (cont.)

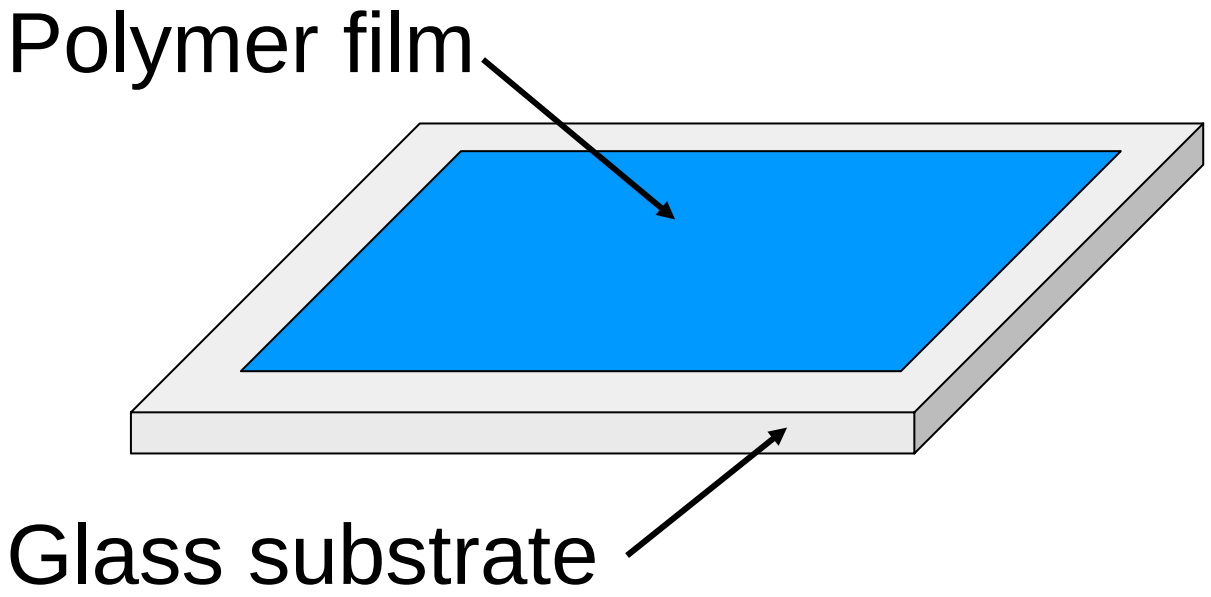
- Exploitation of the MASTER results
- The Research Council of Norway has supported further development of a new prototype
- 1 year project (2006-2007)
- Cooperation with experienced product development partners
- The objective is to develop a product ready for the market

The initial idea

- To develop an early warning system for organic objects (EWO)
- To assess the effect of indoor environment
- Should be a generic effect dosimeter – simulating degradation of organic materials
- Based on recommendations identified by end-users

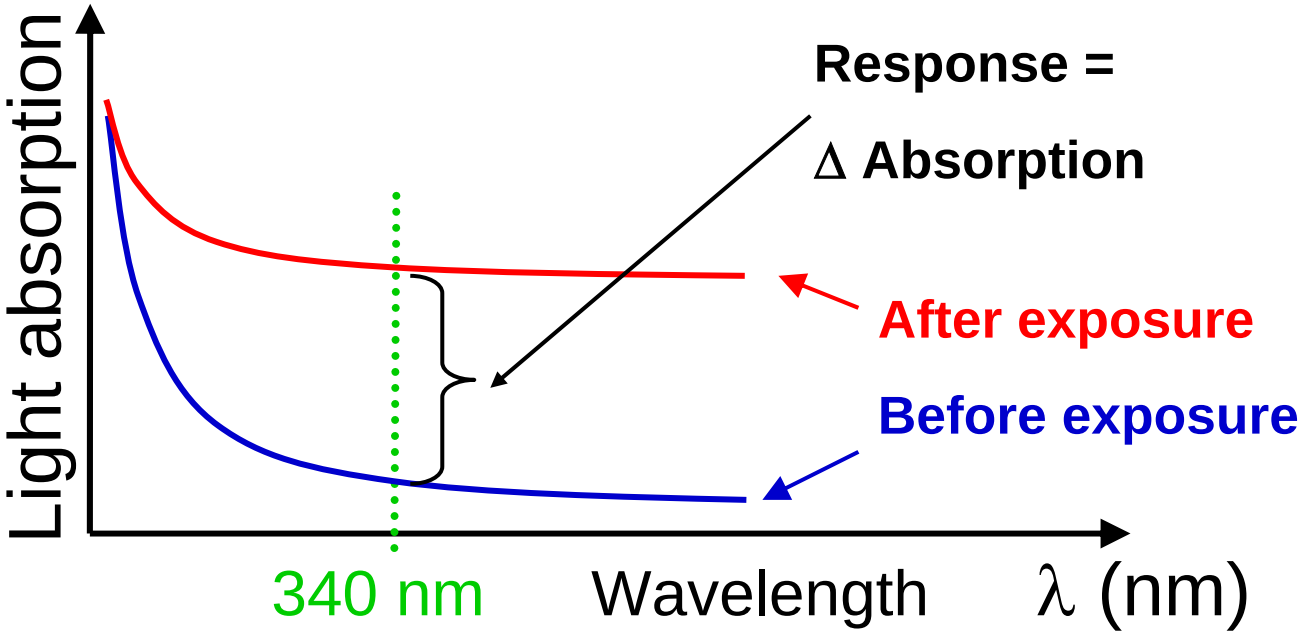
The dosimeter working principle

- The dosimeter is a glass substrate coated with an organic polymer
- The film is applied by spin coating, which gives a uniform film thickness

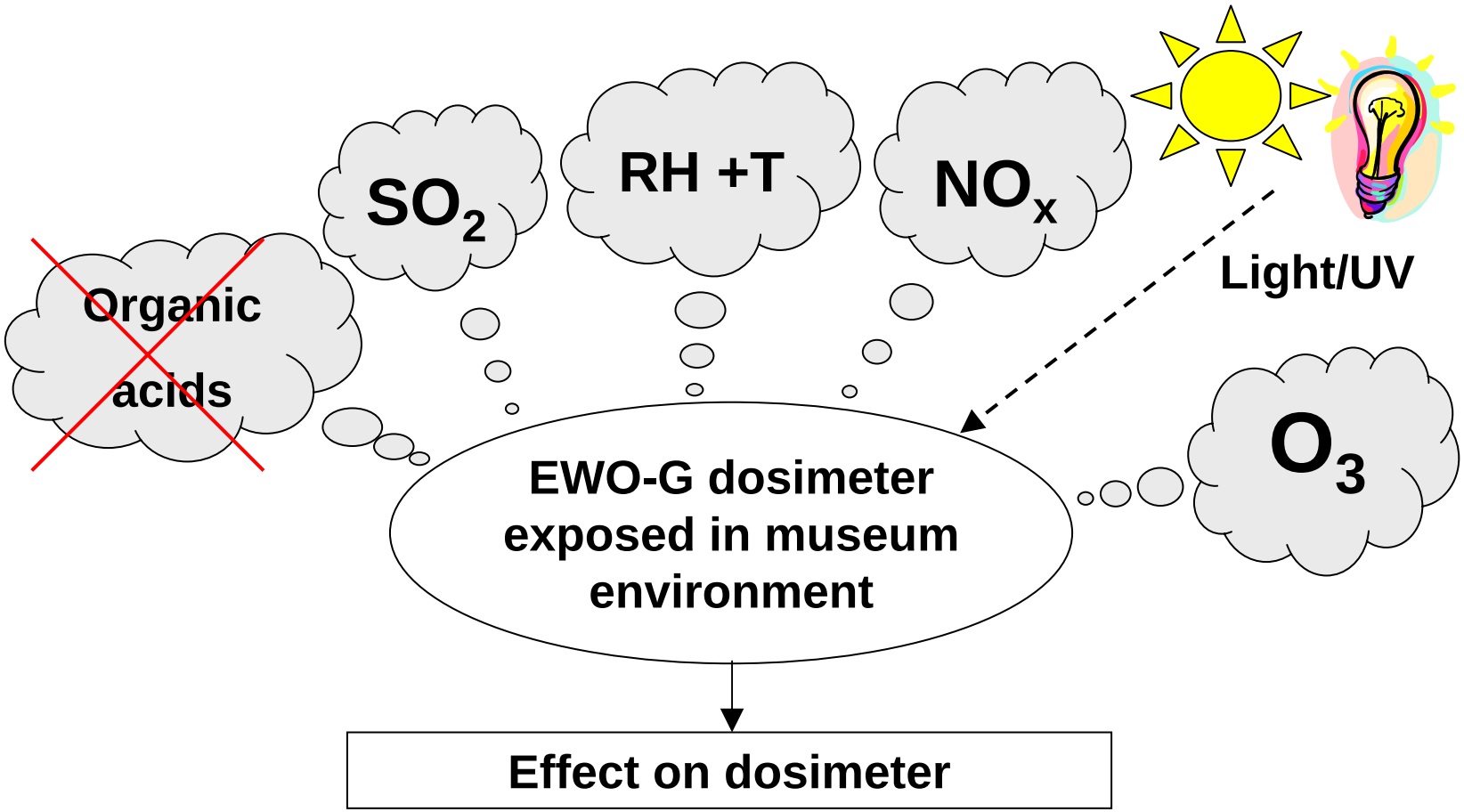


The dosimeter working principle

- The polymer film reacts with air pollutants and becomes less transparent
- The dose is quantified as change in UV absorption (340 nm), using a photo spectrometer



Effect of the environment



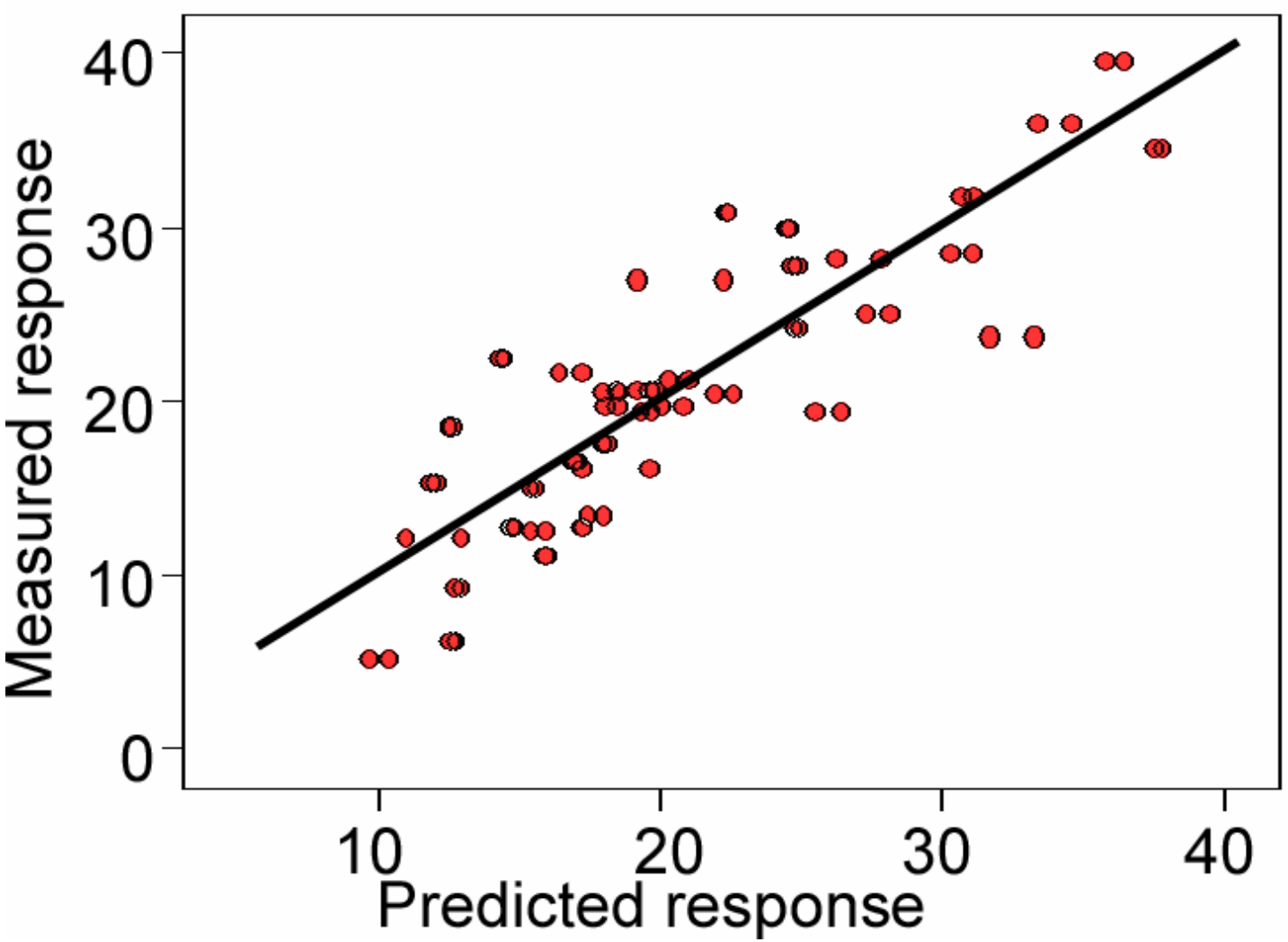
Field test

Trøndelag Folk Museum, Norway

Statistical calibration

EWO effect = 0.75 NO_2 + 1.34 O_3 + 0.51 T + 0.35 UV

(ppb) (ppb) (°C) (mWm^{-2})



Measurment by photo spectrometer

- Field and laboratory samples were measured by photo spectrometer
- Automatic sample holder for up to 8 dosimeters
- Can measure wavelength from 200 – 1100 nm
- The EWO-dosimeter response was measured at 340 nm

Effect thresholds

- Change in absorption is converted to EWO-response level from 1 to 5
- Threshold levels based on available measures for environmental parameters and standards
- The response level has been calibrated to match 5 typical museum environments
- Calibration based on field measurements of:
  NO_X, SO_2, UV, RH/T and O_3

Dosimeter response level

Kind of building	EWO response level				
	1	2	3	4	5
Archive	Expected environment (acceptable)	Environment could be better	Environment is poor	Something is wrong with control	Serious problem with building/control
Purpose built museum	Environment is very good	Expected environment (acceptable)	Environment could be better	Environment is poor	Something is wrong with control
Historic house museum	Excellent environment	Environment is very good	Expected environment (acceptable)	Environment could be better	Environment is poor
Open structure	Dosimeter is not responding	Excellent environment	Environment is very good	Expected environment (acceptable)	Environment could be better
External store with no control	Dosimeter is not responding	Dosimeter is not responding	Excellent environment	Environment is very good	Expected environment (acceptable)

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Response for some pollutants

Exposure time: 3 months

EWO response level		Average concentration NO_2 (ppb)	Average concentration O_3 (ppb)
1	Archive store	1	1.15
2	Purpose built museum	2.5	3
3	Historic building	5	6.5
4	Open structure	10	12.5
5	External store with no control	15	25

End-user requirements

- Visual response
- Easy to use
- Easy to interpret
- Cheap
- Inert
- Small (the dosimeter)
- Durable
- Wide range of sensor sensitivities
- Short-term and long term options
- Able to relate to other kinds of monitoring
- A diagnostic element to the sensor
- All environmental risks to be monitored

End-user requirements

- Have the end-user requirements been fulfilled?
- Measurement by photo spectrometer
  - Expensive
  - Relatively complicated to use
- Is there a need for a simpler dosimeter analyser?

An alternative EWO reader

- Inexpensive
- No experience needed
- Small, can easily be moved
- First prototype is developed
- Second prototype to be developed

Practical demonstration

Analysis of EWO-dosimeter

Dosimeter response level

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Further research

- The EWO-G dosimeter will be used as one of three doismeters in a new EU funded project PROPAINT – ”Improved protection of paintings during exhibition, storage and transit”, starting 2007.
- The other doismeters are: glass dosimeters from the AMECP project and piezoelectric quarto crystal doismeters from the MIMIC project.

Further development of the prototype

- NILU is now working on the developement of a second prototype which should be ready for the market
- In this case we will need your help.

  What are your comments to the EWO-G prototype 1?
- How could it be improved?
- Please contact us during this conference or send an e-mail to emd@nilu.no or gsv@nilu.no

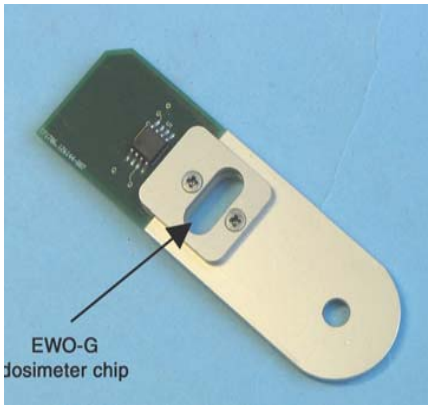
Acknowledgement

- Financial support from:
- For the MASTER project:

  The European Commission, The Norwegian Archive, Library and Museum Authority.
- Thanks to all the partners in the MASTER project for their work
- For this project:

  The Norwegian Research Council
- Thank you for your attention!

Measuring procedure



1. Dosimeter is analysed (initial absorption measurement)
2. Dosimeter is exposed for 3 months
3. Dosimeter is analysed again (second absorption measurement)
4. The response is the change in absorption at 340 nm
5. The result is presented as an EWO-response level

Calibration equation:

EWO-G effect = 0.75 NO_2 + 1.34 O_3 + 0.51 T + 0.35 UV

(ppb) (ppb) (^oC) (mWm^{-2})

Trigger values for environmental parameters and for the EWO-G.

Calibration point		Trigger values					
		NO_2 (ppb)	O_3 (ppb)	UV (mW/m^2)	T (^oC) RH = 45 %	T (^oC) RH = 55 %	T (^oC) RH = 65 %
1	Increasing deterioration ↓	**1**	**1.15**	**1**	20.8	**19.3**	18.2
2		2.5	3	3.75	22.9	21.4	20.2
3		5	6.5	15	24.5	23	21.8
4		10	12.5	37.5	26.8	25.3	24.1
5		15	25	37.5	29.0	27.6	26.2

Interpretation of the EWO-G dosimeter

Example: Museums from MASTER field test

Station	EWO response	Response level
(MASTER field test)	Indoor. Yearly mean. (4*3 months)	
1. Blickling Hall	0.0089	1
2. National Museum of Krakow. The Jan Matejko House.	0.0143	2
3. The Karol Szymanowski Museum, “Atma”, Zakopane	0.0177	3
4. Schwarzwälder Trachtenmuseum, Haslach	0.0186	3
5. The Museum of Decorative Arts & Design, Oslo.	0.0196	3
6. Trøndelag Folk Museum, Trondheim.	0.0212	3
7. Wignacourt Collegiate Museum, Malta.	0.0214	3
8. The Historical Museum of Crete. Iraklion	0.0217	3
9. Haus der Geschichte Baden-Württemberg, Stuttgart	0.0284	4
10. Tower of London, Bloody Tower.	**0.0312**	**4**