Can electrochromic windows deliver neutral daylighting?

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Electrochromic glazing

Electrochromic (EC) glazing changes tint in response to a small applied voltage. It can enable users to control glare from windows with less or even no reliance on window blinds or external shading devices. The ability to control tint dynamically can give users more access to daylight and a continuous view through the window, whilst decreasing energy consumption through the reduction of cooling loads and electric lighting usage.

The De Montfort University Case Study

A case study focussing on the long term user experience of EC glazing was undertaken. The study involved two adjacent offices in a university campus building occupied by faculty support staff. The original windows were replaced by EC windows in 2012. The EC windows in the case study are divided into zones so that different sections of window can be controlled independently (Figure 1).

The glazing under study is capable of four states: Clear (\(T_{\text{clear}} = 62\%\)), fully tinted (\(T_{\text{fully tinted}} = 2\%\)), and two intermediate states (\(T_{\text{intermediate 1}} = 20\%

Figure 1
Hypothesis

A key finding of the case study is that occupants preferred to leave the window panes in their eye-line un-tinted, except when direct sun was visible through those panes. To explore this in more depth, a hypothesis was put forward:

If at least one pane is left un-tinted, the resultant spectrum of daylight in the room is similar to that when none of the glass is tinted.

Theoretical model and field measurements

A general matrix formulation was developed to determine the spectrum that would result from any combination of tinted and un-tinted panes. This model predicted that the spectral transmission curve of one clear pane combined with a number of fully tinted panes is much closer to the curve for the clear state than that for the full-tint state.

To validate this theory, a set of field measurements was taken of daylight spectra in one of the case study rooms from a number of different viewing positions under six different combinations of tinted and untinted panes at different levels of tint.

Figure 3 shows that the measured spectra (blue curves) compare very well with the spectra predicted by the theoretical model (red curves) for each combination. Note that the theoretical spectra use the standard illuminant D55. The vector, \(R\), indicates the combination being tested, e.g. the vector \([3 0 0 5]\) indicates three panes in the clear state, five panes in the fully tinted state, and no panes in either of the intermediate states. (There are a total of eight panes in the room where the measurements were carried out.)

Conclusion

It seems reasonable to speculate that a view containing panels of blue tinted EC glass will be acceptable to occupants (on sunny days) provided that the illumination spectrum contains a significant component of sunlight, i.e. a small proportion of the panels are set to clear.

Further research

More work is needed to explore how the measured spectra relate to the subjective experience of occupants. A procedure using the Farnsworth-Munsell 100 Hue Test has been piloted, and this indicates the potential for a more in-depth study of colour perception under different EC window conditions.

Acknowledgements

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More information can be found in J. Mardaljevic, R. Kelly Waskett, and B. Painter. Neutral daylight illumination with variable transmission glass: Theory and validation. Accepted for publication in Lighting Research and Technology.