Sigrid Eyb-Green* and Ute Henniges

Editorial

<https://doi.org/10.1515/res-2020-0014>

Dear colleagues,

To date, there are still many open questions regarding feasible conservation treatments counteracting paper degradation caused by copper-containing pigments, most notably, verdigris. We are therefore delighted to present this issue of *Restaurator* dedicated to research related to verdigris.

To advance our understanding of the processes taking place during ageing of verdigris, we will first present a paper by Lynn Brostoff and Cynthia Connelly Ryan who explored the natural alteration of both neutral and basic forms of the pigment. We will then progress and introduce two approaches to treating verdigris-damaged paper. Leah Humenuck tested a rigid gel application of benzotriazole (BTA), a complexing agent, on historical samples, while Jasna Malešić et al. studied the efficacy of several commercially available deacidification agents as well as the antioxidant tetrabutylammonium bromide (TBAB). Finally, we conclude this volume with a more art technologically focussed contribution. Maria Plate et al. investigated the green paint layer of a Japanese folding screen from the Edo period and discuss on this basis the production, use and designation of historic Japanese green pigments.

Within the last 10 years, much effort was dedicated to further research verdigris, and one might think that the time has come to compile findings and move forward to recommendations for specific treatments and conservation methodology in general. Recent studies in art technology allow the conclusion that oftentimes, historic recipes and current sample design might not always match. In her study of the alterations of verdigris published in the first volume of *Restaurator* 2020, Brostoff and Connelly Ryan give an overview of historical recipes for verdigris and the resulting compounds. The manufacture of verdigris typically involved the corrosion of copper sheets with acetic acid. Additives and different production methods not only produce a variety of blue to green copper compounds, but also two structurally distinct types of verdigris: the neutral copper acetate monohydrate and a series of basic copper acetate hydroxide salts.

---

*Corresponding author: Sigrid Eyb-Green, Institut für Konservierung – Restaurierung, Akademie der bildenden Künste, Vienna, Austria, E-mail: S.Eyb-Green@akbild.ac.at

Ute Henniges, Staatliche Akademie der Bildenden Künste, Studiengang Konservierung und Restaurierung von Kunstwerken auf Papier, Archiv- und Bibliotheksgut, Stuttgart, Germany

What does this imply for available research results on active treatments of effected papers? Will these new findings on the actual outcome of historic recipes question decades of research when mock-up materials were prepared based on “wrong” copper acetate pigments and far too simplified model papers? Leave alone the question of applying an appropriate accelerated ageing protocol to generate sample materials with degradation comparable to historic originals?

Looking at potential treatment options, we might summarise them as chemical, mechanical and passive approaches. While it is obvious that passive approaches such as improved storage conditions and protective packing and mechanical interventions, e.g. local repair and stabilisation remain unaffected by the actual type of pigment, treatment options that aim at chemical stabilization of the copper containing pigments require a deeper understanding of underlying degradation mechanisms, especially when aiming at the immobilization of the detrimental copper ions. Notably, all chemical treatments will at the same time call for a mechanical stabilisation as well, since to date, no method is known that reconnects cleaved cellulose molecules or restores broken fibres. Therefore, all chemical stabilisation will also benefit from research and development of processes to mechanically stabilise paper.

What do we know so far about chemical interventions? Contrary to iron gall ink corrosion, neither increased alkalinity nor phytates will sufficiently stabilize paper degradation induced by copper ions to justify interventions, especially aqueous ones. Several independent studies agree on this finding. Currently, two chemical interventions were suggested for treatment and have been studied in detail: the antioxidant tetrabutylammonium bromide (TBAB) and the complexing agent benzotriazole (BTA). They aim at different points in the degradation process induced by copper ions: TBAB will act as peroxide decomposer to prevent cellulose from oxidation, and BTA will keep copper ions from reacting. Despite of well-acknowledged uncertainties regarding the actual type of copper acetate present in historic originals, from a chemical point of view, the benefit of these two agents should be independent from the verdigris variety and instead counteract destruction caused by copper ions. Thus, we have two potent chemicals on our hands that have proven in independent studies to protect cellulose from degradation. What keeps us from using them?

It all comes down to two important reasons: lack of long-term experience and lack of approved treatment protocols. This observation is true for both chemical agents, benzotriazole and tetrabutylammonium bromide, engraved by the fact that still no accelerated ageing protocol is available; one that triggers the conversion of freshly prepared verdigris into an aged version of this pigment preventing the formation of black copper oxide typically occurring at elevated temperatures AND at the same time causing degradation comparable to the brittle copper-corroded

papers that we know from our collections. Despite of all these short comings, it seems that now we are at a point to join forces, suggest best practices and share our experiences so far. We emphasise that having treatment options available does not necessarily imply a recommendation for their use without further consideration of ethical implications that accompany all interventions. As Applebaum puts it – it's not about what we could do, but what we should do.

We hope you will enjoy this volume as much as we did when compiling the articles! Our gratitude goes to all authors and reviewers who made this special issue of the *Restaurator* possible by contributing their knowledge and experience. We do hope that this will encourage our readers and colleagues to pursue new ideas on treatment applications and to share them with the scientific community!

Last but not least, we would like to acknowledge all reviewers who shared their valuable feedback on this year's publications (in alphabetical order): Umesh Agarwal, Thorsten Allscher, Mandana Barkeshli, Lynn Brostoff, Paul Garside, Martina Griesser, Birgit Vinther Hansen, Christa Hofmann, Martin Hubbe, Stanisław Ignatowicz, Masamitsu Inaba, Jasna Malešič, Salvador Muñoz-Viñas, Doris Oltrogge, José Luiz Pedersoli Junior, P. Perumal, Giovanna Poggi, Antje Potthast, Pascal Querner, Doris Pitour, Yeni Budi Rachman, and Petra Vavrová.

Thank you!

Regards,
Ute Henniges & Sigrid Eyb-Green