ChemTexts (2026) 12:1
https://doi.org/10.1007/s40828-025-00213-7

LECTURE TEXT

Videos in chemistry research articles

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Received: 25 August 2025 / Accepted: 17 October 2025

Abstract
The use of videos to illustrate advances in the chemical sciences offers numerous benefits that range from enhanced reproducibility of reported findings through to enhanced reader attention and understanding. The nearly concomitant advent of the World Wide Web and of digital photography has long made the publication of laboratory videos accessible at low cost to virtually all researchers. Yet, the use of videos to illustrate advances in chemical research remains low. Besides identifying requirements to create effective chemistry research videos, this study shows why videos in chemistry papers are a crucial resource to enhance the reader's interest in the hypercompetitive context of the digital era of today's research in which attention has long become a scarce resource.

Keywords Videos in chemistry · Academic publishing · Chemistry research · Reproducibility in chemistry

Introduction

The nearly concomitant advent of the World Wide Web and of digital photography in the early 1990s made the insertion of videos in scientific research articles readily accessible to the broad scholarly community. Besides being a valued teaching tool, a video is ideally suited to illustrate a scientific article, for example a new method, because it "includes information such as color, position, duration, shape and motion" [1].

With its multistep experimental procedures, chemistry in principle is ideally suited to benefit from the possibility to visualize processes and methods using videos. Indeed, only on YouTube (a freely accessible video platform with 2.7 billion users as of March 2025) [2], some 1619 "channels" were found to have produced English-language chemistry content between 2005 and 2023 [3]. Such videos were mostly produced by independent individuals and chiefly focused on chemistry education [3].

In general, the use of videos to illustrate advances in the chemical sciences offers numerous benefits. Such benefits range from enhanced reproducibility of reported findings through to enhanced interest from the readership in the hypercompetitive context of today's research in which attention has long become a scarce resource. Surprisingly, however, the use of videos to illustrate advances reported in chemistry research articles was and remains low. Even the peer-reviewed *Journal of Visualized Experiments* (JoVE) established in late 2006, by late March 2025 included 3399 biology video articles [4], and only 701 chemistry video articles [5].

Academic publishers active in science, technology and engineering reacted to the advent of the internet and digital videos by allowing authors to insert a short video as supplementary material. Authors could insert a link to a video posted online either on the journal's server or in a video repository. For videos published in the journal's server, publishers set limitations to the video file size (in byte, B). As broadband and available memory expanded, such limitations were progressively loosened. For example, as of March 2025 the journal *Nature* (published by

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Published online: 19 November 2025

Springer Nature) allows authors to publish in their articles video files up to 30 MB per file, with the maximum cumulative size of all videos not exceeding 150 MB [6].

Researchers in science, technology and engineering readily showed their interest in research videos. For instance, studying 1808 academic publications published between 2006 and 2011 that cited at least one YouTube video, Kousha and co-workers in 2012 found a steady upward growth in citing online videos [7]. The team also reported that most videos cited by research articles in science (78%) and in medicine and health sciences (77%) had direct scientific (laboratory experiments) or scientific-related content (academic lectures or education).

Today, prestigious chemistry journals such as *The Journal of Physical Chemistry Letters* publish "Perspective" videos highlighting "new and emerging research in the field of physical chemistry" [8]. Similarly, when some of us published in *Chemical Communications* a study on enhanced polysaccharide nanofibres obtained via oxidation over a commercial sol–gel catalyst [9], the journal asked us to produce a brief video illustrating the article's content "to learn more from the authors publishing this urgent research" [10].

With the rapid uptake of generative artificial intelligence (AI) in scholarly communication, some journals today even offer AI-generated and author-approved video alerts consisting of short videos, aimed at reaching the public, including policy makers, created using content directly from the article (e.g. [11]).

In brief, videos in chemistry are regularly used worldwide. Students, for instance, are frequently asked to create videos on selected topics to show evidence of their new competences and presentation skills [12]; instructors use video lectures as a complementary educational channel alternative to face-to-face lectures [13], as well as educational tools complementary to textbooks and laboratory lectures. To understand the relevance of chemistry educational videos, suffice it to learn that just one YouTube channel in Spanish ("Breaking Vlad"), created in mid 2015, as of March 2025 featured more than 1500 videos and had accumulated over 580 million views, with 1.51 million subscribers [14].

Besides identifying requirements to create effective videos to illustrate advances in chemistry research articles, this study shows why videos in chemistry papers are a crucial resource to enhance the reader's interest in the hypercompetitive digital era context of today's research in which attention has long become a scarce resource. Evidence from doctoral studies, indeed, suggests that effective mentoring of doctoral students in chemistry should comprise practice-oriented education on open and impactful academic publishing in the digital era [15].

Effective videos in different subfields of chemistry research

In the following, we highlight selected videos illustrating advances in different fields of today's chemistry research inserted in recent research articles published in open access (OA) form in reputable chemistry and materials science journals.

Catalysis

To illustrate the structural evolution dynamic of the redispersion on NiRu alloy nanoparticles (NPs) on $Ni_{10}Ru_4/TiO_2$ hydrogenation catalyst in the temperature range from 23 to 500 °C under H_2, Zou et al. inserted in their article published in *Angewandte Chemie International Edition* a video displaying the in situ environment transmission electron microscopy (ETEM) outcomes during heating [16]. Having substantial size (183.3 MB) and lasting 24 s, the video (in mp4 format) allowed the team to identify the mechanism of the redispersion process during the heating phase, especially between 400 and 500 °C, where complete redispersion process includes the disintegration of initial particles to the formation of newly smaller particles without structural changes of TiO_2.

In brief, the video (Fig. 1) shows that the NiRu alloys are torn apart into smaller ones by specific interactions

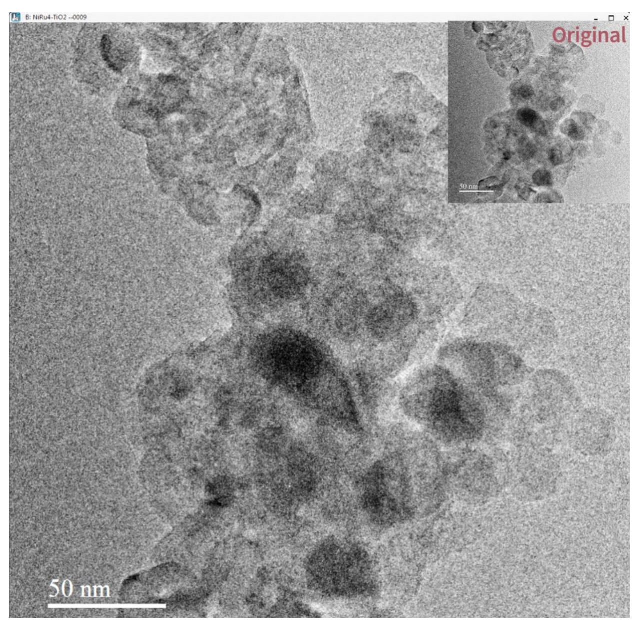

Fig. 1 Screenshot of the video illustrating changes in the $Ni_{10}Ru_4/TiO_2$ hydrogenation catalyst in the temperature range from 23 to 500 °C (Reproduced from Ref. [16], Creative Commons License CC BY-NC-ND 4.0)

with 'tearing effect' on the alloy–support interfaces. Initially the original structure remains still, but the video then shows the evolution of the catalyst TEM images upon heating. The video achieves its communication objective by insertion on the upper right corner of the original TEM image of the catalyst.

Electrochemistry

To illustrate new research aimed at developing efficient sulfur-based cathodes in lithium–sulfur batteries, Li and co-workers inserted in their research article published in *Angewandte Chemie International Edition* two videos based on *operando* optical microscopy to gain insights into the behaviour of sulfur/sulfide species [17]. Sulfur-based cathodes offer a high theoretical capacity of 1675 mAh g^{-1} but do not reach it mainly because conventional electrode production relies on mixing of components into weakly coordinated slurries.

One video displays cells assembled with a PVDF@KB/S electrode (a polyvinylidene difluoride-coated novel imine polymer@KB/S cathode based on a one-pot, in situ polymerization of imine-based polymer encapsulating Ketjen black/sulfur, KB/S, particles on an aluminium surface). The apparent mobility of sulfur (the "sulfur shuttle" effect) limits the performance of current in sulfur-based electrodes, leading to battery degradation.

In contrast, another video (Fig. 2) shows the cell with a TAPB-TA@KBS electrode displaying only a pale yellowish coloration of the separator, namely higher sulfur retention and thus lower sulfur-shuttling.

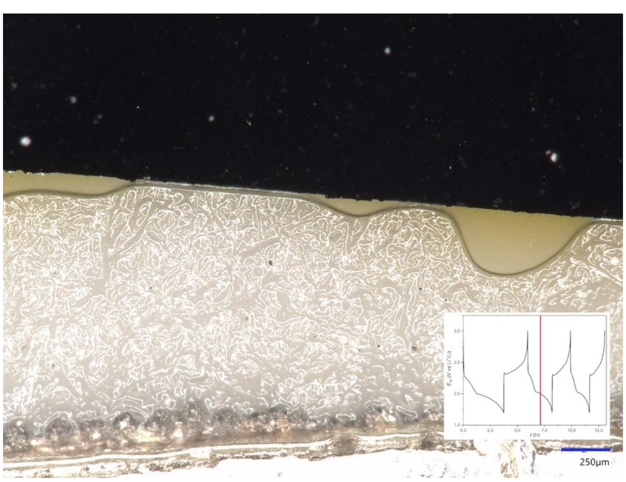

Fig. 2 Screenshot of the video illustrating changes in electrochemical cell with a TAPB-TA@KBS electrode showing only a pale yellowish coloration of the separator (Reproduced from Ref. [17], Creative Commons License CC BY 4.0)

Synthetic organic chemistry

To illustrate a new reaction monitoring method based on NMR, Lloyd-Jones and Flook inserted in the supplementary information (SI) file of their article published in *The Journal of Organic Chemistry* a link to a YouTube video [18]. Entitled "How To Guide: Parameters and Data Processing for NMR Reaction Monitoring" and lasting about 19 min, the video presents a step-by-step guide including four parts (preparation for reaction monitoring, reaction monitoring, spectra processing, integral data and time processing).

Similarly, to illustrate how a webcam positioned inside the reactor box, combined with a small LED lamp to improve visibility, allows visual monitoring of a photochemical benzylic bromination by producing a video (Fig. 3) of the quench fluidic module, Kappe et al. in 2020 inserted in the SI section of their article published in *Organic Process Research & Development* a video corresponding to diverse entries of reaction conditions described in Table 2 of the article [19].

In this case, it is especially useful for adapting the sodium thiosulfate flow rate to ensure effective bromine quenching (e.g. whether all Br_2 is being quenched or if no Br_2 is formed). The video of the quench fluidic modules allows visual monitoring of the reaction, estimation of the bromine concentration entering the quench fluidic module and the efficacy of the quench, thus acting as a semiquantitative visual process analytical technology tool.

Green and sustainable chemistry

To illustrate the flow-and-attach effect of oil palm empty fruit bunch (EFB), the lignocellulosic residue from the palm oil milling process, converted into fibreboard using cellulose fibres as a binder, Lee et al. inserted a video in the SI of their

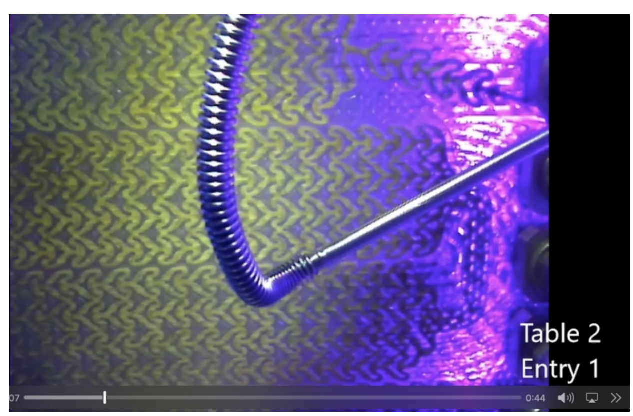

Fig. 3 Frame of the video of quench fluidic module during experimental runs (Reproduced from Ref. [19], Creative Commons License CC BY 4.0)

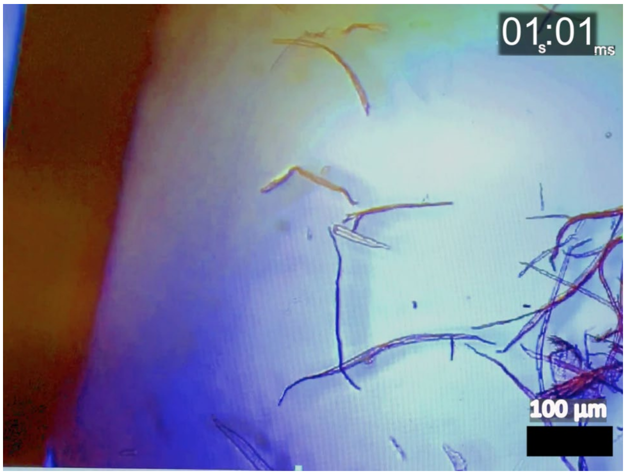

Fig. 4 Frame of the video of a single EFB fibre immersed in a droplet of pulp suspension (Reproduced from Ref. [20], Creative Commons License CC BY 4.0)

article published by *ChemSusChem* [20]. Showing a single dry EFB fibre immersed in a droplet of pulp suspension, the video (Fig. 4) was recorded using a scanning electron microscope (SEM).

Lasting 2.11 s, the video clearly shows an agglomerate of "hairy" cellulose fibres moving towards the surface of the EFB fibre within a second after initial contact with the pulp suspension.

This brief colour video nicely illustrates how, driven by water absorption through capillary action, the suspended (hairy) cellulose fibres flow and attach themselves onto the surface of the EFB fibres. Upon mild drying and wet pressing, inter (hairy) cellulose fibre bonding via van der Waals' interaction, hydrogen bonding and fibre/molecular entanglement binds the EFB fibres together providing the newly obtained fibreboard with superior mechanical properties.

Pointing to complete circularity of the new approach, the hairy cellulose fibres were produced using a recirculating colloid mill passing bleached wood waste pulp through a 1.5-kW recirculating colloid mill.

Similarly, willing to show the simplicity of the LimoFish process to convert fish (anchovy) processing waste into valued fish oil and organic fertilizer in just three steps, the most important of which is treatment of milled waste with *d*-limonene (followed by oil separation, and mild drying of the solid), Pagliaro et al. inserted in their article published in *ChemSusSchem* a link to a freely accessible video posted at Dropbox. The video shows (Fig. 5) how an electric blender is used to mix and homogenize the frozen anchovy leftovers stirred at room temperature along with an aliquot of limonene, to afford a semi-solid grey purée [21].

Similarly, to show the mechanical robustness of a new PI/CNT organic anode composed of polyimide (PI) nanosheets

Fig. 5 Frame of the video showing the key extraction step of the LimoFish process (Reproduced from Ref. [21], Creative Commons License)

and carbon nanotubes (CNTs) suitable for producing thick anodes (e.g. 100 mg cm^{-2} and 1 mm) of exceptional cycle life (up to 380,000 cycles) in supercapacitors and ultrahigh areal capacities in batteries, Wang and co-workers included in the SI section of their article published in *Advanced Materials* a video of a free-fall experiment of the electrode from a height of 2 m (Fig. 6) [22].

The video provides evidence that, after hitting the ground, the anode remains intact.

Materials chemistry

To show the interfacial crystallization (IFC), the assembly and formation of membrane-like crystalline sheets from Nle, a peptoid monomer amide and leucine analogue with a branched aliphatic side chain, Lau et al. inserted in the SI of their article published in *Langmuir* a link to a video posted at Google Drive [23]. The video shows that when a solution of Nle bromide salt (i.e. Nle.HBr) in warm 2:1 v/v acetonitrile (ACN)/methanol (MeOH) ($T \geq 50$ °C) was left to slowly cool and evaporate in a beaker covered with a watch glass, floating, transparent, crystalline sheets formed at the air–liquid interface (Fig. 7).

The video shows how these crystals eventually merge to form large structures that fill the liquid surface (approx. 15.5 cm^2 in the case of the 50-mL beaker used) suggesting that IFC may by used in the quick and effective formation of interface-sealing supramolecular barriers, based on simple monomer chemistry (peptoid and amino acid amide monomers).

Educational outcomes

Reviewing selected videos illustrating advances in different fields of today's chemistry research inserted in recent research articles published in reputable journals shows that

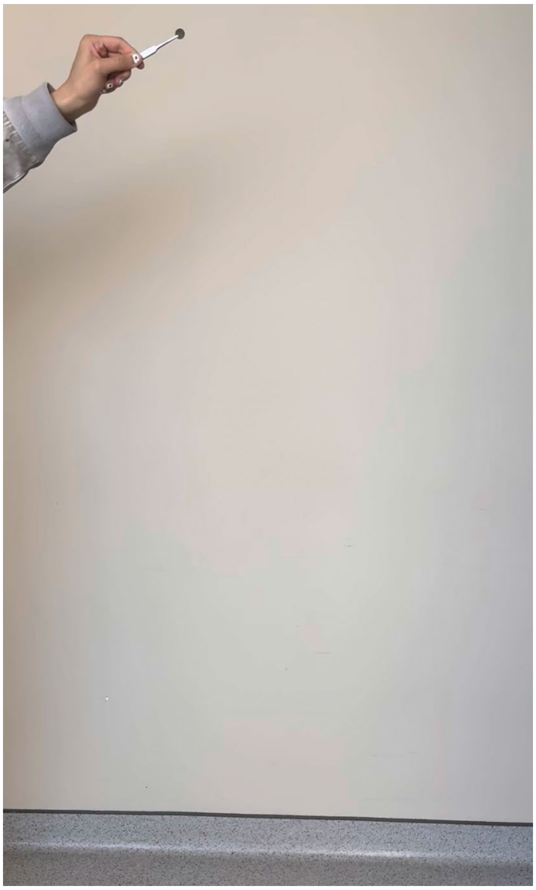

Fig. 6 Frame of the video showing the free-fall experiment of PI/CNT electrode from a height of 2 m (Reproduced from Ref. [22], Creative Commons License CC BY-NC 4.0)

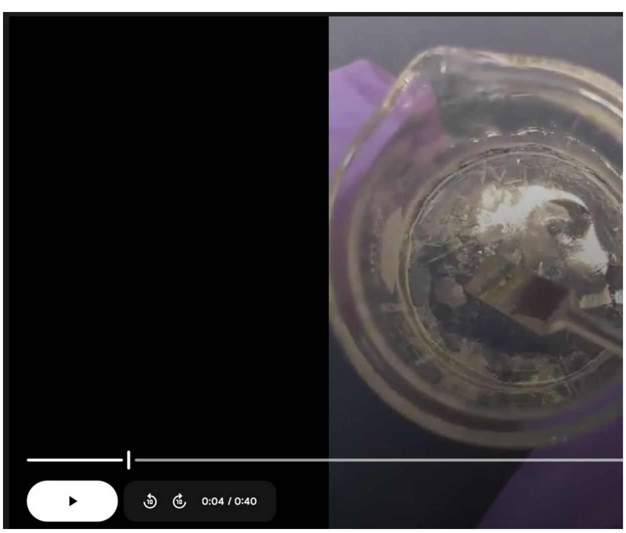

Fig. 7 Screenshot of the video showing crystalline sheets of Nle bromide salt formed via IFC on the surface of 2:1 v/v ACN/MeOH (Reproduced from Ref. [23], Creative Commons License CC-BY 4.0)

the requirements for producing effective videos to illustrate research articles in the chemical sciences are analogous to those of effective videos in chemistry education. For the latter, empirical surveys and cognitive theory suggest that content needs to be relevant to the topic, with a brief video made of only meaningful and relevant images (no animations, graphics, and text on screen) [24]. This is not surprising. The conceptual methodology of chemistry is based on visualization and association. Accordingly, a video showing either a macroscopic or microscopic process allows the chemist watching the video to better visualize the process and the underlying phenomena, eventually associating the images at a symbolic level with the mental images that become the mental tools (the symbolic representation) typically manipulated by the chemist's mind to create new substances and understand the underlying microscopic (often, but not always, molecular) chemical phenomena [25].

> "What chemists really do is to create mental images of the substances they wish to create—and then manipulate these forms (shapes) in a rational manner to verify if they could fit to afford the desired substance [25]."

Accordingly, a purposeful video inserted in a chemistry research article helps to integrate the microscopic and macroscopic levels of representation [26], thereby enhancing the ability of users watching the video "to develop sound mental models of molecular reality" [27], namely the key to understanding chemistry.

Practice-oriented education of doctoral students in the chemical sciences on scholarly communication is crucial to effective PhD student mentoring [15]. Such education will therefore include education on effective chemistry research video-making. First, a research video is aimed at peers, and not at the general public. Its aim is to visualize a new protocol, a new technique, or a new achievement made possible through a new material, process or device. Table 1 summarizes the requirements for producing such videos based on web usability principles as well as advice from leading professionals in science animation.

As noted by one of such professional, the use of different camera angles and shots adds variety and interest. Hence, an effective video should include close-ups, and wide shots to visually explain complex concepts and enhance viewer interest [28].

Lighting needs to be checked before filming. To avoid blurred images, the smartphone or camera is ideally placed on a rigid surface.

In general, there is no need to use video editing software. The latter is used when producing a video abstract or when producing a video illustrating a research team's work. Effective videos are truly useful tools to improve the societal impact of research to have research not only read by peers but also "watched, shared, and discussed" [29]. In such

Table 1 Selected requirements and aims of effective videos for chemistry research articles

Requirement	Aim
When a professional camera is not available, use a smartphone equipped with an adequate camera	Produce a high-resolution video
Vary your camera shots (use different camera angles and include close-ups, and wide shots)	Visually explain complex concepts, add variety and interest
Check lighting before filming	Produce a properly lit video
Insert the video in the main text of the article as a thumbnail	Enhance the viewer's attention by allowing direct insight into the video content
Produce the video in commonly used video file formats	Prevent poor accessibility to the video (in user testing many users come across a video that does not load)

videos, aimed at the general public, a professional voiceover reads an easy-to-understand and engaging audio illustrating the video (the "animation") presenting the topic. This is a crucially relevant aspect of today's chemistry research vividly rendered by Canada-based biochemist Braun, the founder of the NileRed "channel" posting chemistry videos in English on YouTube:

> "I find that chemistry is often taught poorly or without a purpose. Because of this, people tend to lose interest and sometimes even start to hate it. In each video that I make, I try to balance theory with purpose. My goal is to capture the natural beauty of chemistry in fun and interesting ways" [30].

Showing the scope of producing and sharing effective chemistry videos, in a few years the channel has reached nearly nine million subscribers. On the other hand, as mentioned above, inserting a video in a chemistry research article shows evidence of a fact or a new process presented in the article, thereby enhancing the reproducibility of the reported research findings [31].

Hence, rather than inserting the video as a link in the SI section at the bottom of the article or, even more remotely, within the SI file, journal publishers (and research chemists producing their manuscripts directly in journal article format) should consider the opportunity to insert the video in the main text of the article as a thumbnail. The latter is a static image used to represent the video typically consisting of a still image from the middle or end, rather than the beginning, of the video clip being presented [32].

Finally, the thumbnail will be linked directly to the video uploaded on the publisher server or posted on any reliable and freely accessible video repository. The video format, too, remains an important technical issue. For example, Schade, a web usability professional, noted in 2014 how:

> "From an accessibility perspective, providing content as a video can limit access to the information contained in this format for anyone who cannot see or hear the content. In addition, videos break. In testing we've seen many a user run across a video that won't load, doesn't appear, can't be played, or freezes [32]".

When one of us in mid October 2025 using the browser (Safari version 18.3.1) installed on a modern computer (Apple iMac equipped with M4 processor running macOS Sequoia 15.3.2) tried to open the videos in AVI format linked at the bottom of an article published in 2017 by *ACS Applied Materials & Interfaces* (at https://doi.org/10.1021/acsami.7b04406/suppl_file/am7b04406_si_002.avi) [33], the outcome was a black screen with a broken grey arrow. Nor was the technical issue due to the incompatible nature of the computer used to open the video in AVI format. For example, the same computer smoothly opened the first video (Movie_S1.avi, at https://doi.org/10.1021/jacs.1c00651/suppl_file/ja1c00651_si_002.avi) linked in the SI section of another study published in 2021 by the *Journal of American Chemical Society* [34].

In general, inserting a video in a chemistry research article can be seen as a means to improve reproducibility, a key objective of Open Science, and the reader's attention. Empirical evidence from numerous recent studies suggests that videos in research articles substantially improve readers' attention [35, 36].

On the other hand, from publishing OA articles and preprints [37], to data sharing [38], research chemists have been reluctant to embrace the Open Science principles and tools. Slowly, this situation is changing. For example, by early 2025 the number of preprints posted at *ChemRxiv* crossed the 30,000 threshold. The number of preprints on the same platform by late September 2021 was 10,000.

Calling for humble learning from other disciplines, in the uptake of videos in research articles we suggest to emulate life scientists. Their flagship journal *eLife*, for instance, inserts videos as thumbnails in the main text of the article, with their own caption as normally happens with images inserted as article figures. For instance, a 2017 article included 15 videos, each with its own caption in both the HTML and PDF version [39]. In the HTML online version, it is enough to click on the thumbnail to play any one of the videos. Commenting on the videos, all three reviewers wrote to the journal editor that the imaging was "brilliant" [40].

Evidence from doctoral studies suggests that effective mentoring of doctoral students in chemistry should comprise practice-oriented education on scholarly communication, particularly on open and impactful academic publishing [41]. Such education conducted in the Open Science era will therefore include education on effective chemistry research video-making. Generation Z (those born between the mid-to-late 1990s and the early 2010s) consists of "digital natives", namely the first generation to have been born after the mass adoption of the internet and social media. Chemistry undergraduate or graduate students belonging to Generation Z do not need to be taught by the older generation how to create and share videos, as they routinely create, exchange and discuss online videos: both short (on platforms like Snapchat, TikTok and Instagram) [42] and long-format videos (on platforms such as Rumble and YouTube) [43].

Conclusions

This study shows that the use of videos to illustrate advances reported in chemistry research articles remains limited. This is unfortunate because chemistry, with its crucially important multistep experimental procedures through which the synthesis and analysis of new and known substances is conducted, ideally benefits from the possibility to visualize processes and methods using videos.

As smartphones with advanced cameras became widely adopted and younger researchers entered chemistry research, the number of articles embedding research videos increased.

In general, academic publishers active in the chemical sciences allow authors to insert videos in their research articles. Such videos are usually inserted as supplementary material (the Supplementary Information file), either as a link to a video uploaded on the publisher's server (with limitations to the file size) or as a link to a video posted in a freely accessible video repository.

Reviewing selected videos illustrating advances in different subfields of today's chemistry research from recent research articles published by reputable journals, this study identifies the requirements for producing effective chemistry research videos based on web usability principles as well as advice from leading professionals in science animation.

Written by chemistry scholars belonging to Generation X (those born between 1965 and 1980), this study does not pretend to teach effective video making to digital natives engaged in chemistry research. It rather aims to underscore the relevance of videos in today's (and tomorrow's) chemistry research articles and, accordingly, the related relevance of web usability and accessibility principles in their use. As such, the study is aimed at further informing the long-awaited education of chemistry faculty on mentoring doctoral students.

Requirements listed in Table 1, and the concepts of this openly accessible study, will hopefully contribute to further shaping long-awaited faculty education on mentoring doctoral students in the chemical sciences when teaching academic publishing to their protegées.

Author contributions All authors contributed equally to this manuscript.

Funding Open access funding provided by Consiglio Nazionale Delle Ricerche (CNR) within the CRUI-CARE Agreement.

Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

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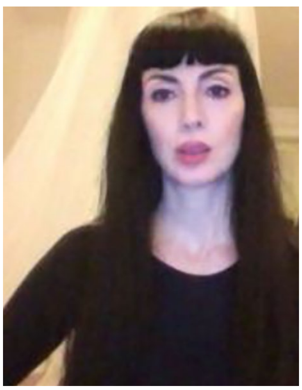

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