

ORIGINAL ARTICLE

Theorizing Chemical Rhetoric: Toward an Articulation of Chemistry as a Public Vocabulary

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Chemistry has been a pivotal part of scientific discovery and human life for centuries. This essay argues that chemical terms, tropes, figures, appeals, and narratives serve as powerful rhetorical features of public discourse. From affinities and atoms to dark matter and radioactivity, chemical rhetoric fulfills a central organizing function in contemporary society and shapes how people deliberate and delineate their identities, relationships, and communities. The present research demarcates chemical rhetoric as a form of nonexpert communication, and explicates its association with chemistry's disciplinary history, as well as with technical chemical language's grounding in key focal concepts. More specifically, it maps out a framework for defining and theorizing chemical rhetoric through three, interconnected lenses: historical-ecological, conceptual articulation, and vernacular. The overarching goal in this essay is to create an infrastructure for investigating chemistry's longitudinal circulation and emergence as a shared public vocabulary.

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Chemistry as a discipline has been deemed both technically complex and, at the same time, undeniably central to contemporary society (Levere, 2001). Since its rise during the Enlightenment, modern chemistry's language, theories, and ideologies have come to permeate not only specialized, professional, and industrial spheres of communication but also the broader rhetorical culture and lay interactions. Indeed, chemical rhetoric—which refers to the use of chemical terms, tropes, figures, appeals, and/or narratives in nonexpert discourse—has been recognized as a predominant and consistent organizing force across historical and contemporary mainstream communication (Crosland, 2006; Sjöström, 2007). Operating outside

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the strictures of the scientific literacy continuum as upheld by [Wagner \(2007\)](#) and [Gross \(1994\)](#), chemical rhetoric involves the engagement of chemistry as a shared communicative resource for public, nontechnical exchange concerning any subject, a resource that is interlinked with the technical science communication of chemistry (i.e., expert-to-expert technical interaction; expert-to-public translational discourse) but is not equivalent to it.

For example, metaphors and appeals to atoms, elements, matter, reactions, and substances—to name just a few—have long infused conversations, commentary, and news articles on any number of topics both with and without content-oriented ties to chemical study and practice. Simple appeals to “a chemistry” have been employed successfully to justify the creation and funding of sweeping technological and biomedical initiatives (see, for instance, [Auletta, 2014](#); [Josephson, 2005](#)), as well as major cultural and international revolutions ([Simon, 2005](#)). Much mainstream, political speech hinges on references to catalysts, affinities, and the combustion of oppositional forces. Moreover, chemical rhetoric animates popular culture via any number of contemporary books (e.g., *Atomic habits*; [Clear, 2018](#)), films (e.g., *The fifth element*; [Ledoux & Besson, 1997](#)), and even band names (e.g., My Chemical Romance), a pattern that can be traced back at least to early-nineteenth century literature with the publication of Johann von Goethe’s acclaimed social novel *Elective Affinities* and romantic poet Friedrich Schlegel’s “chemical combinatorics” ([Chaouli, 2002](#), pp. 1–2; [Hagen & Kagen, 2013](#)). In light of chemical rhetoric’s pervasiveness and appeal across time and situation, I contend that research explicating its features, modes, and evolutions is essential to the broader theoretical project of mapping communication and its processes.

To date, scholars representing a range of disciplines have made important inquiries into the technical uses and pedagogies of chemical language ([Fahnestock, 2009](#); [Lippincott, 2003](#); [Lundgren & Bensaude-Vincent, 2000](#); [Markic & Childs, 2016](#)). However, they have yet to explore central theoretical questions linking technical chemistry and its pedagogies to chemical rhetoric broadly conceived. That these particular inquiries into what [Taylor \(1996\)](#) termed “democratic discourses of science” remain largely uninvestigated is problematic not only because of chemical rhetoric’s prevalence (p. 374), but also because, as [Fahnestock \(2002\)](#) explained, rhetorical figures and ideas do more than offer playful variety to a discourse; they epitomize and exemplify certain lines of reasoning (pp. xi, 24). The figures, ideographs, and overarching discursive structures through which people communicate inevitably shape how they think, argue, and behave ([Jasanoff, 2004](#); [Laclau & Mouffe, 1985](#)). In this respect, a predominant rhetorical culture of chemistry imposes certain means for configuring the world that other communicative infrastructures do not. The central goal of the present essay is to articulate a framework for identifying that culture, mapping its means and interactions, and investigating chemical rhetoric in both its historical and contemporary manifestations. I maintain that establishing a theoretical framework for studying chemical rhetoric in this way will facilitate the creation of the kinds of analytic tools that are essential for

interrogating the central controversies of times past, present, and future. In what follows, I first define chemical rhetoric in more detail before considering chemical rhetoric as an especially apt, multi-faceted, and as-yet-underexplored area of research. Then, I review communication scholarship that speaks in peripheral ways to chemical rhetoric's manifestations and articulate a trajectory for engaging chemical rhetoric theoretically in terms of its communicative functions, possibilities, and implications.

Defining and finding chemical rhetoric

Given the dearth of scholarship in this area, the clearest way to define and begin identifying chemical rhetoric may be to establish, first, what chemical rhetoric is not. For one, chemical rhetoric is not the technical language that has served as linguistic currency among those disciplined in chemistry from the beginning of the late eighteenth-century until the present day, a currency traced by science historians such as [Beretta \(1993\)](#), [Crosland \(1962, 2006\)](#), and [Simon \(2002\)](#) and described as a specialist nomenclature grounded in systemic empiricism and composition-oriented schemas. Indeed, chemical rhetoric is distinct from (but nonetheless fundamentally related to) this coded discourse that scientists, pharmacists, practitioners, and other chemistry experts employ to interact in scholarly, professional contexts. Chemical rhetoric is also not equivalent (although, again, it is related) to chemical pedagogy, which encompasses a diffusionist model of communication dedicated to instructing students and other nonexperts in the chemical sciences and has been considered in terms of its generic expectations, modes of identification, and underlying values (see, for instance, [Hoffman, 2017](#); [Lundgren & Bensaude-Vincent, 2000](#)). Although technical, chemical language and chemical pedagogy are certainly sources through which chemical rhetoric emerges and evolves (offering necessary context and entrée into its study), chemical rhetoric's employment is tied not to technical, scientific accuracy—as are these other modes of discourse—but, instead, to the communicative framework it provides for guiding interactions about any number of issues and topics.

Moreover, chemical rhetoric refers to something distinct from the more general “rhetoric of science” theorized by scholars such as [Gross \(1990\)](#), which conceptualizes technical science rhetoric broadly and—in defiance of Aristotelian logic—highlights its persuasive properties and functions (p. 18). Chemical rhetoric diverges from this conceptualization, on one level, because it articulates scientific terms and ideas not as they are used by experts to persuasively construct science but as they form a “public vocabulary” and thereby constitute the “acceptable words, myths, and characterizations used for warranting social behavior in a community” ([Condit, 1994](#), p. 228). On another level, chemical rhetoric is distinguished from an ecumenical rhetoric of science in that it heeds a particular scientific discipline's unique communicative resources. In light of this latter distinction, chemical rhetoric aligns with and even parallels research initiatives explicating the rhetoric and ideologies of

other individual scientific fields. For example, [Lyne \(1990\)](#) theorized the rhetoric of biology specifically as a “bio-rhetoric” or a “strategy for inventing and organizing discourses about biology in such a way that they mesh with the discourses of social, political, or moral life” (p. 38). His work calls attention to the “potential for borrowing rhetorical resources from one domain and using them in another” (p. 38), thus making, in this case, biological issues “*discursively available*” to considerations and conversations outside the bounds of technical science ([Lyne, 1987](#), p. 508 [emphasis in original]; see also, [Brookey, 2001](#)). The tenor of this inquiry—which operationalizes technical, biological language as a widespread and culturally dependent rhetorical tool—overlaps a great deal with chemical rhetoric as a mode for theoretical inquiry. The key difference between the two is a focus on biology-specific discursive resources versus chemistry-specific resources, and the contention that chemistry-specific resources especially have an ingrained history of mainstream pervasiveness and persuasive vigor. Correspondingly, notable scholarship has focused on the rhetoric of physics specifically, which overlaps with what might be termed a rhetoric of chemistry because both scientific areas deal in the study of matter and engage corresponding approaches and investigations ([Desilet, 1999](#); [Gross, 1995](#)). What differs in this case, then, is not so much the field-specific linguistic tools (as physics is grounded in chemical terminology to the point that the two are arguably indecipherable at the level of nontechnical interaction), but that scholarship on the rhetoric of physics thus far has focused less on the employment of physics rhetoric culturally than it has on technical communication within and about physics as a science.

In this respect, chemical rhetoric engages the spirit of field-dependent specificity inherent in existing rhetoric of physics inquiries but it does so with a focused turn toward public or common rhetorical culture, which encompasses what [Condit and Lucaites \(1993\)](#) described as “public argumentation,” or the “domain of rhetorical interaction through which a community actively negotiates its common needs and interests,” and “rhetorical culture,” or the “range of linguistic usages available to those who . . . share a common interest in their collective life” (p. xii). From this perspective, whereas something like a rhetoric of chemistry might involve the study of technical communication within and about chemistry as a science, the study of chemical rhetoric involves the identification, explication, and theorization of chemically oriented terms, tropes, figures, arguments, and narratives as they circulate in public, nonspecialized interactions, with the idea of public-ness or publicity referring not to an idealized, Habermas-ian public sphere but rather to what [Hauser \(1999\)](#) described as a shared social world with common referents and overlapping experiences and resources. Metaphorical appeals to an interpersonal relationship as a bond, or as atomic or elemental, provide clear examples of chemical rhetoric in action, as do widespread cultural narratives that draw from the idea that issues such as human fertility and reproductive health can be understood colloquially in terms of a fixed energy system and attraction between partners ([Jensen, 2015b](#)). In these instances, chemical words and ideas offer those without chemical training

powerful discursive resources for communicating with others who are also not chemistry experts.

Those looking to identify and theorize about chemical rhetoric have a number of primary sources from which to draw. Chemical rhetoric is evident and accessible in any public discourse targeting nonexpert audiences. It spans everything from presidential address and social media platforms to healthcare-related documents and public-relations materials. Newspapers, blogs, advertisements, television programs, and public debates, to name just a few out of many possible sources, serve as chemical rhetoric wellsprings in that they reflect and uphold mainstream communicative norms. Moreover, chemical rhetoric can also be found in lay talk and therefore may be accessed through processes capable of encapsulating such talk including ethnography and oral history. Archival documents such as correspondence, diaries, and other unpublished papers provide access to chemical rhetoric along these lines. Correspondingly, an argument could be made that authentic representations of colloquial discourse in fictionalized accounts offer sufficient proxy for chemical rhetoric in a way similar to that offered by first-person memoirs or nonfiction writing. On the whole, these diverse fragments of discourse confer rich opportunities for scholars to decipher chemical rhetoric for what it is and how it functions at the level of an overarching public vocabulary, a task that is made all the more compelling by the development of modern chemistry as an inherently public-oriented science that has long been positioned in close relationship to and with nonexpert engagement.

A science formed in and of the public

When modern chemistry emerged as a discipline in the mid-eighteenth century, its knowledge-base was upheld in terms of its public nature and scope. Chemistry's inscription in the marrow of rhetorical culture today can be attributed, in part, to what Golinski (1999) described as the "legacy of Enlightenment public science" wherein chemical knowledge was consecrated scientifically only after it had been performed outside of the laboratory and even replicated by members of the literate public (p. 8). This tradition was espoused in later years by public figure-chemists such as Humphry Davy and Justus von Liebig who, in the case of the former, engaged in open displays of self-experimentation and characterized chemical inquiry as a poetic endeavor with revelations and moral implications so sublime that it all-but mandated an unrestricted audience (Gabriel, 2010; Golinski, 2011; Ross, 2002). In this way, chemistry's processes and findings were portrayed as too spectacular—and therefore not verifiable—if kept from the attentions of nonexperts. As Werrett (2011) illustrated, chemical demonstrations and displays for nonexpert audiences functioned during this time to delineate a more general, collective language that was subsequently adopted broadly for the discussion of topics such as nature and society.

Scholars working in what has recently been termed the "chemical humanities" have cited this disciplinary history as they explain the need for more research

considering chemistry not as only, or primarily, a technical construct but as a product of—and in—public culture (Hagen & Kagen, 2013, p. 11). Yet calls for this type of investigation are complicated by the fact that, especially over the last century, chemical rhetoric often emerges as at-odds with itself. On one hand, chemical language bestows rich and diverse inventional resources for nonexpert communication, whereas, on the other, society at large suffers from chemical skepticism and even “chemophobia” in that lay people infamously shy away from products, publications, and events where chemistry headlines (Hartings & Fahy, 2011; Laszlo, 2007, p. 674). Chemistry’s more recent associations with warfare, addiction, toxicity, and pollution have done much to scare from its province nonexperts (Bensaude-Vincent & Simon, 2008), those who had hitherto been relied upon to serve as the discipline’s most important witnesses. For this reason, chemistry as both a scientific field and an industry is often situated today as entirely distinct from—or only to the detriment of—lay experiences, whereas it also feeds the broader culture prolifically with ways, means, and content for communicating and thereby understanding the world and its components.

In this context, research into chemical rhetoric as a public discourse or vocabulary is especially challenging to conceptualize. Moreover, much like the field of rhetoric writ large (Gaonkar, 1990), chemistry too has been described as a “discipline that seems to be everywhere and nowhere at once” (Bensaude-Vincent & Stengers, 1996, p. 5). Known as the “central science” for its role in connecting other disciplinary knowledge (Metz, 2009), chemistry’s focus on the very composition of matter, its elements, and their properties (Siegfried, 2002), requires attention to the smallest of details but always in light of the scope of a vast and interconnected whole. The methods by which technical chemical language guide this feat are difficult to enact or trace on their own (Gross, Harmon, & Reidy, 2002; Baake, 2012); and the process of extending that work to analyze how chemical concepts and ideas are engaged outside the technical sphere is arguably even more onerous. Despite—or, perhaps, because of—these challenges, the need for scholarly explication of chemistry as central to mainstream rhetorical culture is pressing. In an era of pandemics, global conflict, racial strife, economic uncertainty, and environmental crisis, chemical rhetoric has emerged as fundamental to the communicative configuration of the human experience. In the subsequent section, I review existing communication-oriented scholarship that engages these issues peripherally and thereby offers springboards for articulating a theoretical framework for elucidating chemical rhetoric.

Related communication inquiries and insights

Beyond technical and pedagogical accounts of chemical language, existing communication research speaking to something like, or otherwise associated with, chemical rhetoric can be divided into three emphases. First, scholarship has explored technical, chemical-science language and communication as it plays out at the level of public policy and controversy, tracing how interactions in this context marry

technical, scientific information with public concern and engagement. Although this research explores communication explicitly about chemistry as a science and therefore is not equivalent to chemical rhetoric research, it offers a compelling link to considerations of chemical rhetoric as a public vocabulary in that it explicates a likely mode by which technical chemistry communication becomes intertwined with the broader rhetorical culture. For example, research in this area explores depictions of chemical information by experts for, and on-behalf of, regulatory agencies and stakeholders, and provides insight into the kinds of public messages that circulate about chemistry in terms of health and environmental risk (see, for instance, Kinsella, Andreas, & Endres, 2015; Paroske, 2012). Scholarship in this area also examines how scientists communicate directly with nonexpert publics concerning issues of chemical risk without the mediation of an organization or regulatory agency (Molinatti & Simonneau, 2015), as well as the role that media plays in shaping public perceptions of chemical policy issues (Brossard, 2009; Thomas et al., 2016) and how—based on those perceptions—nonexperts talk about and evaluate chemical risk and/or are intimidated into policy-oriented acquiescence (Farrell & Goodnight, 1981; Scherer & Cho, 2003; Wander, 1976). Overall, this body of work theorizes chemical information as subject matter in need of translation for nonexpert consumption and engagement, and it does so because technical, chemical language is by definition exclusive and opaque (Crosland, 1962). In terms of considering chemistry in and of a broader rhetorical culture, the focus of these investigations on the touchpoints of technical, chemical language and public discourse provide clues about the chemical rhetoric “life cycle” (Sidler, 2018, p. 102), particularly in cases where scholars consider the co-production of chemical knowledge among experts and nonexperts (see, e.g., Barnett, 2015; Peebles, 2011). Questions about where chemical rhetoric comes from and how it comes to be, as well as how it evolves, garner significant investigative traction from these inquiries’ discernments related to, for instance, the finding that both technical science communication and mainstream science engagement are not exclusively top-down enterprises best conceptualized in terms of deficit (Grabill & Simmons, 1998; Gross, 1994; Wynn, 2017). These insights suggest the need to consider chemical rhetoric’s formation as a multilateral process with multiple modes of development, circulation, and contextual meaning.

Second, existing scholarship employs a “popularization” approach to investigate popular-culture representations of chemistry (Stewart, 2009, p. 124), thereby highlighting yet another way that nonexpert engagement with chemical terms and ideas is sustained and perpetuated. Often this research considers the pedagogical aspects of these representations in terms of what the media got “right” about chemistry in a technical sense and, correspondingly, popular culture’s potential for providing “informal chemical education” via translation and accommodation (Charney, 2003; Fahnestock, 1986; Stockmayer & Gilbert, 2002, p. 143). There are also investigations in this area that explore popular-culture framings of chemistry in a more general, distributive sense as it espouses chemistry’s associations with

industry, consumerism, (im)morality, and defiance of nature (Fahy, 2013; Jensen, 2015b). Scholarship on chemical marketing augments this conversation as well, demonstrating how companies have advertised chemical concepts and ideas as inherently problem-solving, progressive, and applicable to daily life (Cozen, 2010; Thornton, 2011). Given popular culture's role as something of a barometer for societal norms (Dow, 1996), this research recommends an avenue for theorizing about chemical rhetoric's content and style that resists to some extent traditional top-down or linear conceptualizations, with popular media representations positioned as more or less reflective of authentic nonexpert engagements.

Finally, a third body of literature that relates to chemical rhetoric involves the employment of chemical terms and ideas as conceptual guides for theorizing communication processes. This includes research on communication in terms of frames such as energy and elements (e.g., Ingraham, 2018; Qin, 2014), a practice that Hawhee and Holding (2010) have traced back to the eighteenth century when rhetorically educated philosophical chemists such as Joseph Priestley and Gilbert Austin employed concepts from their scientific experimentation to delineate theories of materialist rhetoricity, thereby "drawing to rhetoric's domain the likes of air, heat, water, electricity, and vibration" (p. 265). Scholarship in this tradition models how technical chemical concepts have been, and continue to be, employed productively in contexts other than chemistry's technical spheres, thereby providing valuable insight into the subtle mechanics of chemical rhetoric. Moreover, this research, too, suggests that chemical rhetoric is as much the product of scientific influence as it is—or has the potential to be—the catalyst for scientific innovation at the technical level (see, for instance, Reyes' [2004] treatment of the scientific concept "infinitesimal" as "invented" by nonempirical rhetorical interactions before adoption by technical scientific communities [pp. 163–164]). Again, then, an existing research line lends credence to the idea that the employment of technical scientific terms in nonexpert contexts functions multidimensionally and, therefore, is best represented by interventions that account for chemical rhetoric as source, mediator, and recipient of influence and invention.

A framework for studying chemical rhetoric

Drawing from these findings, I delineate a three-pronged framework for investigating chemical rhetoric as it has emerged and evolved into a public vocabulary. The different levels or degrees of analytic, tenet-driven intervention outlined below mirror the interconnected ways in which chemical rhetoric coordinates and warrants interactions in the broader culture.

Historical-ecological lens

The initial prong of the framework considers chemical rhetoric from the lens of scientific chemistry's specific history and involves analyzing discursive traces of that

history to identify touchpoints or encounters at which it may have overlapped with emergent public vocabularies of chemistry. These points, or discursive “encrustations” as Condit (1994) described them (p. 8), are evident when technical chemical language aligns with ideas, myths, and narratives that are employed in nonexpert discourse, although the alignment resists linearity and direct diffusion and so may be neither synchronous nor synonymous. This lens is upheld as ecological in the sense that its mode of deciphering inter-sphere touchpoints draws from Edbauer’s (2005) approach to exploring the circulation and movement of rhetorical appeals, not in terms of static situations but, rather, in terms of an evolving, inter-connected rhetorical ecology of discourses, processes, materials, transformations, and encounters.

In the case at hand, the rhetorical ecology under investigation is demarcated by the transition the discipline underwent during the Enlightenment in its evolution from alchemy—with its appeals to mystic philosophy and secretive communities of knowledge—to modern chemistry—with its standardized methodologies and publicly substantiated experimentation (Rattansi & Clericuzio, 1994). Recent scholarship has revealed that this transition was not as stark as it has long been made out to be in that many of alchemy’s insights were ultimately integrated into chemistry’s disciplinary agenda and remain ingrained there today; to be sure, some of the most touted early chemists including Sir Isaac Newton and Robert Boyle were also dedicated alchemists (Principe, 2000). In this respect, chemical rhetoric is implicated in the mutually defining relationship between these two modes of inquiry, as well as the tensions evoked by alchemy’s essential mystique and chemistry’s emergent and public-facing professionalization. That alchemical principles did not stop circulating with the emergence of the modern chemical discipline but, instead, evolved and percolated in and through that emergence demonstrates the importance of investigating chemical rhetoric in terms of what Bucchi (2008) described as a deviation model that resists progressive, linear interpretations of science as cultural phenomena.¹

By way of example, an investigation grounded in the tenets of the historical-ecological lens might involve the communicative explication of gold as an ideograph for deep-seated cultural narratives related to prestige, authority, and divine appointment. Research along these lines would involve tracing the symbolic role that gold played in alchemic knowledge traditions, which concentrated on identifying and orchestrating the means for transmuting base metals such as lead into gold and deciphered gold as a manifestation of purity and perfection (Principe, 2015). It would relate those findings to gold’s economic rise in and over time according to specific cultural exigencies and competing valuations (Tcha, 2005), as well as the research programs it ignited in the realm of modern chemistry (Gimeno, 2008), and, most importantly, its cultural ideations driving and motivating social and individual actions related to—for instance—gold rushes, Olympic recognitions, and political appeals to national exceptionalism and colonization. This process of tracing and analyzing gold’s touchpoints in terms of vivid, historically grounded cultural narratives would function necessarily to upend key persuasive and affective tropes

animating chemical rhetoric in years past. Moreover, this process would disclose such narratives' "extended half-li[ves]" into and through contemporary moments that—in the case of gold and its transmutation specifically—involves tales of nanotechnological interventions that may seem to lend credence to alchemical predictions and even cultural diagnoses (Alekklett et al., 1981; Edbauer, 2005, p. 13; Murph, Larsen, & Lascola, 2016). Such an exploration would foreground Aldersey-Williams' (2011) contention that chemistry tells powerful "cultural stories" that circulate and garner ongoing, emergent meanings through the interconnections of technical language and social processes (p. 7).

From a methodological perspective, chemical rhetoric as envisioned through an historical–ecological lens fosters an analytical process grounded procedurally in the tenets of rhetorical history but with a more specific emphasis than what guides generalized historiographical accounts in the rhetoric of science.² Investigations into chemical rhetoric are differentiated for their undeviating focus on evidence concerning the development of a shared, unspecialized form of expression grounded in chemical terms and ideals that was (and is) both highly coded and infinitely adaptable and applicable in the context of nontechnical exchange. In the study of gold, scholars might explicate how nontechnical discourses such as—for instance—political addresses invoke this term and its corollaries to persuade and otherwise guide broader meaning-making and social interaction.³ Given this focus, one significant methodological note for research in this vein is that, whereas this work will indeed draw from the analysis of primary sources housed in science-history repositories, research on chemical rhetoric in history will also draw heavily from historical collections, documents, and materials that are not overtly chemistry-oriented. To be sure, the traces of historical chemical rhetoric will not necessarily be found first and foremost in chemistry textbooks, industry guides, or scientific publications but, rather, in the many mainstream discourses that circulated in society more generally ranging from product advertisements, popular media representations, and public health messages to petitions, meeting minutes, and even maps or architectural plans.

In this respect, locating and identifying historical chemical rhetoric will involve procedural challenges. For instance, special collection indexes are far more likely to be guided by subject matter than by style or form of communication, and archives, on the whole, are limited in that they are composed of what Derrida (1996) characterized as—at best—"lovely impressions" of life and its real-time interactions (p. 11). Thus, scholars of chemical rhetoric, particularly those working from a historical–ecological lens and thus incapable of gathering interview, ethnographic, or survey data, will need to develop aptitudes for reading between the lines of existing finding aids similar to what scholars such as Finnegan (2006) and Morris (2006) have respectively discussed in their own depictions of against-the-grain archival research (see also, Chaudhuri, Katz, & Perry, 2010). This demanding process is emblematic of the unexpected, deviational qualities of chemical rhetoric's communicative capacities in and over time.

Conceptual articulation lens

The next prong of the framework at hand relates closely to the first and involves theorizing chemical rhetoric in terms of the articulation of key concepts. Modern chemistry has been recognized as a conceptual discipline that is—despite its well-earned reputation for rigor and complexity—grounded in relatively few focal concepts (Taber, 2002). Among the most central of these are atoms, elements, matter, reactions, and substances (Mierzecki, 1991), concepts that are so vital to modern chemical theory and practice that they can be neither overlooked nor easily exchanged in disciplinary chemical dealing. In technical chemical nomenclature, these concepts are implicated within networks of other, associated concepts and broader narratives, and compelling research is emerging that aims essentially to map those connections and their meanings and implications (e.g., Hendry, 2010; Kaya & Erduran, 2013). This scholarship offers guidance and insight for the study of potential focal concepts and their articulations at the level of chemical rhetoric. There are a number of indications that it is not just in the technical sphere that these specific concepts and their offshoots guide and shape interaction, in part because—being at the heart of both key scientific and regulatory controversies—they are much repeated and ultimately co-constructed in broader societal contexts. Indeed, references related to, for instance, atomic disagreements, elemental truths, the truth of the matter, and reactionary politics, are the very substance of contemporary “everyday talk” (Tracy & Robles, 2013, p. 5). These concepts may therefore offer an infrastructure for public discourse as well, an infrastructure that communication scholars are uniquely positioned to trace and employ to map chemical rhetoric’s renderings. With this in mind, the conceptual articulation prong of inquiry invoked here involves the identification of focal concepts in chemical rhetoric—which may or may not align with those recognized in technical chemical language—and a call to trace one or more, locate their uses and expressions, and link them in terms of associated concepts, arguments, and overarching configurations.

Furthermore, just as chemical science is defined by rapid evolution wherein its focal concepts shift, transform, and emerge reconstituted in a variety of new sub-disciplines and technical contexts (Holbrook & Garneau-Tsodikova, 2017), this same evolutionary process is also fundamental to chemical rhetoric. What this means for a research platform dedicated to investigating chemical rhetoric is, first, that conceptual mapping of chemical terms and ideas must be enveloped within a highly contextualized approach to analysis that considers how and why meanings might differ in otherwise diverse and changing circumstances and, second, that scholars must explore these concepts particularly as they circulate outside of conversations having to do with chemical science proper. That is, they must resist the urge to use the technical as a heuristic for nonexpert use, or to employ one expression of nonexpert use as a direct, enduring heuristic for another. This work will build from existing popular culture analyses concerning chemistry, though the emphasis will be not on whether the representations are technically correct but whether and how they create specific and persuasive meanings. In addition, the focus on conceptual mapping in this trajectory will position those doing research on this front to resist

the individualist tradition of science historiography (and rhetorical history) by foregrounding the discursive networks upholding scientific concepts rather than the specific communication of isolated individuals and texts.

Central to this inquiry is the identification of points at which technical chemistry and chemical rhetoric diverge conceptually as this sheds light on the relationship between the two and their distinct communicative features and functions. Shifts in what Kuhn (1962) famously described as scientific paradigms are rich sources of such happenings, as many (but not all) scientists veer in new directions laden with novel terminology whereas nonexperts—not being privy at least initially to the shift—do not. Kim (2003), for instance, illustrated how appeals to affinity, which were common in both technical and nonexpert discourse throughout most of the eighteenth century, dissipated from many technical circles with the publication of Lavoisier's *Elements of Chemistry* in 1789. Yet long after this shift in the technical sphere, the language of affinity remained in widespread, nuanced use in nonscientific contexts, according to Kim, and was adopted broadly in support of a more general natural philosophy. Similar arguments have been upheld by research on pneumatic chemistry and, more specifically, the replacement of phlogiston theory with oxygen theory in the late eighteenth century, with scholars arguing that appeals to phlogiston remained even in some technical chemical circles in the years that followed (Allchin, 1992; Chang, 2009). Both of these examples are historical in nature and so the conceptual mapping that they entail overlaps considerably with the tenets upheld in the historical-ecological prong of the chemical rhetoric framework. However, the study of more recent scientific shifts in technical chemical language and in chemical rhetoric (such as the development and use of nano-chemistry in the twentieth and twenty-first centuries) will necessarily incorporate more contemporary, emergent explorations of communication patterns as they unfold in recent and on-going times.

The methodology fostered by investigations employing this lens is guided by the tenets of articulation theory, which DeLuca (1999) outlined in the context of rhetorical studies scholarship specifically and research on discourse more generally. Drawing from the writings of Laclau and Mouffe (1985), DeLuca (1999) described this process by which “floating signifiers” (in this case, concepts) link with other discourses and are thereby modified in terms of their meanings, though never in a fixed sense and always through a complex navigation of specific, hegemonically derived antagonisms (p. 335). On the whole, what makes this orientation especially fitting for the study of chemical rhetoric is its attention to the articulated construction of meaning in an “open social field” as opposed to that constituted by exclusive technical communities (p. 344), as well as its mode for considering discursive warrants in terms of *phronesis*, or practical sense, and *doxa*, or common belief.

Vernacular lens

The third prong of the chemical rhetoric framework links the historical and conceptual appeals evident in public discourse to that of everyday talk and/or vernacular

discourse. Tracy and Robles (2013) defined everyday talk as the “ordinary kinds of communicating people do in schools, workplaces, and shops; at public meetings; and when they are at home or with their friends” (p. 5). It involves the sorts of unspecialized interactions that Goodnight (1982) aligned with the personal sphere of argumentation, and it is commonly equated with vernacular discourse, which refers most generally to “speech that resonates within local communities” (Ono & Sloop, 1995, p. 20) in that it incorporates how “everyday, common folk,” as Ingraham (2013) put it, “speak, how they interact, what discourse informs their daily routines in the communities and places they live and work, and how these communities and places likewise inform their discourse” (p. 2). If there is, indeed, a broader rhetorical culture of chemistry ingrained within contemporary society, then research will reveal that it circulates and evolves not only at the level of public interaction but also in and through interpersonal, localized, everyday sorts of exchanges that encompass face-to-face encounters as well as those that are technologically mediated. It will also reveal—as scholars Allen (2007), Flores (2018), and Ono and Sloop (2002) have articulated—that those interactions differ in important ways according to the particular, intersectional subject positioning of those involved and the communities in which they live and interact; and that attending to those variances in terms of race, ethnicity, sex, gender, nation of origin, sexuality, class, religion, and more is crucial to the project of conceptualizing chemical rhetoric as a truly public—rather than exclusive, elitist—vocabulary.⁴

To date, there has been an emergence of excellent scholarship on vernacular science as it relates to citizen scientists and lay scientific engagement (e.g., Mehlenbacher, 2019; Wynn, 2017). In this research, findings are conceptualized either in light of how nonexperts reckon with technical science, and/or something like Wagner’s (2007) “vernacular science knowledge,” which evokes a middle ground between scientific expertise and scientific ignorance that allows nonexperts to navigate their daily lives as they overlap explicitly with issues of science (p. 7). Central to these explorations, as in much chemical pedagogy and representation scholarship, is an assessment of technical accuracy or learning that is supported (or not) by specific modes of engagement. By contrast, the vernacular lens of the chemical rhetoric framework highlights the creation of specific meanings through the local invocation of chemical terms, figures, narratives, and the like as those meanings emerge informally among everyday people, regardless of technical, scientific accuracy or the specific content of their talk.

For instance, existing scholarship maps the 150-year history and evolution of the periodic table of elements and, increasingly, the table’s evolving cultural and iconic roles as they relate primarily to technical science and industry (e.g., Gordin, 2019; Scerri, 2019; Shaik, Cremades, & Alvarez, 2019). Research guided by the vernacular lens would adjust that line of investigation to decipher localized, informal interactions that invoke the periodic table, thereby assessing the forms these invocations take and how they create meaning in the context of everyday lives and local communities. Findings on this front may relate to what has emerged as a thriving consumer

culture dedicated to the periodic table (as well as other chemistry-oriented symbols such as DNA's double-helix model) wherein it is not uncommon to find shirts, mugs, beach towels, shower curtains, and any number of other commodities sporting a version of its likeness. These products are manufactured largely at the mass level and so might be conceptualized as a broader public discourse (and thus investigated via the historical-ecological or the conceptual articulation lenses), but it could also be argued that, when individuals integrate these products into their homes and everyday interactions by purchasing, using, and referencing them, they employ them informally in ways that align with the communicative goals of their localized, day-to-day engagements. This is also or even especially true when the periodic table is rendered in a modified form on these products to present an organization of personal interests related to, for instance, fast-food menu items or television-show characters or types of work-related burn-out; or when individual elements on the table are reappropriated and reorganized to communicate a range of word-play jokes and puns, as well as messages in support of any number of ideas and topics. In these cases, technical chemistry is not what is at primary issue. The periodic table seems to function as a reference or backdrop for the deliverance of other interpersonal identity-oriented messages and symbols, a backdrop that gestures toward perhaps the same type of periodicity and predictability evidenced in the periodic table's technical illuminations or even a specific ideological leaning, paradigm, or proclivity. Whatever the case, central to a study along these lines would be the incorporation of comparison wherein different instantiations of the periodic table as employed by specific individuals and communities in their day-to-day interactions are delineated in light of alignment or contrast with other vernacular instantiations and/or broader public discourses.

In terms of methodology, this lens fosters an approach grounded in the critical rhetorical analysis of vernacular, which involves not only identifying and cataloguing examples of localized chemical rhetoric but also considering them via attention to power, expressions of counter-hegemony, and distinctions between and across communities (McGee, 1990; McKerrow, 1989; Ono & Sloop, 1995). The engagement of diverse data-analytic approaches, especially those involving ethnography and participant-observation as they have been enunciated through a rhetorical field methods perspective (McKinnon, Asen, & Chávez, 2016; Middleton, Senda-Cook, & Endres, 2011), will be necessary in many cases because the vernacular study of chemical rhetoric depends on accessing communication as it unfolds in unplanned, in situ scenarios.

Conclusion

The present essay is grounded in the contention that chemical rhetoric is a form of nonexpert communication that is distinct from (though intricately related to) technical chemical language and chemical pedagogy, and that it has long functioned as a powerful public vocabulary featuring chemical terms, tropes, figures, appeals,

and/or narratives. The chemical rhetoric framework delineated here offers an invitation and a guiding trajectory for identifying and theorizing chemical rhetoric via the enactment of specific, interconnected lenses for analysis. The historical–ecological lens it posits is guided by tenets that highlight, first, chemistry’s history as both public-facing and emergent from the mystique and metaphysical philosophy of alchemy. Second, this lens underscores encounters between technical chemical language in history and public vocabularies of chemistry that move, percolate, and otherwise deviate across time and place in an overarching rhetorical ecology. Correspondingly, the posited conceptual articulation lens draws from tenets evident in articulation theory that involve identifying key concepts in both technical chemical language and chemical rhetoric, mapping and comparing their uses through conceptual inter-relationships, and exploring the points at which technical and public terminology diverge. Finally, the framework’s vernacular lens emerges from a critical rhetoric orientation dedicated to exploring localized, community-specific manifestations of chemical rhetoric as they play out in informal interactions and across diverse peoples. These three prongs of inquiry support the development of a comprehensive, though evolving, theoretical account of chemical rhetoric, an account that illustrates the command of chemical rhetoric’s scope, and the ways in which it shapes cultural possibilities and imaginaries.

It is important to note that the chemical rhetoric research trajectory links not only to the rhetorical or critical study of science and culture, but also to the thriving field of empirical, social-scientific scholarship dedicated to explicating what has recently been termed the “science of science communication” (Fischhoff & Scheufele, 2013). Scholars working in this area employ empirical testing to decipher the most effective means by which technically validated, scientific information can be communicated accurately to and with nonexperts, thereby reducing public misperceptions about scientific issues (Jamieson, Kahan, & Scheufele, 2017). This research has informed and inspired the creation of influential disciplinary directives published by the National Academies of Sciences, Engineering, and Medicine (2016) speaking to, for instance, *Effective Chemistry Communication in Informal Environments*. One central finding across research in the science of science communication is that effective public science communication is a multidirectional process and thus must account for the literacies, perceptions, and communicative resources that nonexperts bring to the table (e.g., Akin & Scheufele, 2017; Yeo et al., 2015). Chemical rhetoric is undeniably one such resource and one that may in some cases actually complicate the technical interpretive process because it does not translate directly to technical science language or even necessarily vernacular science knowledge. In this respect, accounting for chemical rhetoric as a central organizing factor in the broader rhetorical culture will enhance scholars of the science of science communication’s ability to create increasingly intelligible and cogent communicative interventions. For instance, studies in this area upholding the “quality of the science communication environment” in the context of childhood vaccination promotion may find that “*science communication pathologies*” are

circulated persuasively through the guise of specific modes of everyday, vernacular chemical rhetoric (Kahan, 2017, p. 421 [emphasis in original]), and that their diffusion is therefore most effectively enacted via chemical rhetoric as well. Moreover, as Johnson and Xenos' (2019) model of transdisciplinary science communication suggests, research on chemical rhetoric proper will offer the most robust account of its subject if it is reciprocally informed by the science of science communication's findings concerning technical science communication and effective outreach interventions.

At a theoretical level, the chemical rhetoric framework is designed as an answer to calls for continued and creative theorizing about science communication in relationship to and with broader society. Bucchi (2008) contended that science never emerges apart from the society in which it functions and therefore must be theorized in relationship to that society. Chemical rhetoric is a clear manifestation of this mutuality, yet one that until now has been mostly overlooked, perhaps exactly for that reason. Those who study and theorize about science communication do not frequently consider nonscientific communication and contexts, and those who study mainstream discourse and interpersonal interaction rarely conceptualize that research in terms of scientific communication. The case made here in the process of identifying the omnipresence and power of chemical rhetoric across time, place, and context is that communication theory-building must increasingly occur across science and society rather than in terms of one or the other, and that doing so from multiple perspectives and approaches will be key to accounting for and improving society's communicative, chemical future.

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Notes

1. On percolation as a mode for engaging historical analysis, see Jensen (2015a, 2016); Serres (1995).
2. For recent models of historiographical accounts in the rhetoric of science that draw from the tenets of rhetorical history and employ an ecological- or relational-oriented perspective, see Johnson (2015); Jensen (2016); and Koerber (2018).

3. Studies by Harpine (2001) and Jarratt (2019) offer illuminating glimpses into what this type of focus may entail.
4. See Das (2019), Enck-Wanzer (2011), and Molloy (2015), for examples, of research attending to intersectional subjectivities and science-oriented or -adjacent vernacular.

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