

An Investigation on the Activity Pattern of Alchemical Transmutations

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Abstract—The objective of this work is to reexamine some physicochemical aspects of alleged old alchemical transmutations performed by adding a small amount of a substance called in the texts Philosophers' Stone (PS) over melted base metals. A set of six basic physical parameters can be identified in the extant reports that describe these processes: the nature and weight of the initial base metal, the nature and weight of the resulting noble metal, the weight of the PS and the duration of the trial. A total of eight alchemical transmutation events from the 17th to 19th centuries have been identified where these six parameters are described with sufficient clarity. Following the data included in these reports, the transmuting power of the PS is defined as the weight ratio between the noble metal obtained and the PS used. It has been found that the transmuting power and the duration of the alchemical transmutation follow an inverse correlation. This activity pattern is similar to that generally shown by conventional catalysts. Some independent evidence has been found in the alchemical literature in support of this pattern. This behaviour is in agreement with the attribution by alchemical authors to the PS of the ability to accelerate the natural “ripening” of base metals that convert them into noble ones.

Keywords: alchemical transmutations—catalysis

Introduction

The scholarly studies on alchemy are usually restricted to the historical, artistic, philosophical or psychological aspects of this old, human activity. Although the alchemy view of the world, despite frequently obscure expressions, certainly plays an important role in the history of man's conception of nature, the material aspects of alchemy are taken only, at the best, as the grounds where the modern chemistry is rooted. However, what remains as the most specific core of Western alchemy is the quest for the so called Philosophers' Stone (PS), a certain substance alleged to change base metals into noble ones, silver or gold. Claims of success in making such material can be profusely found in Western alchemical literature. A noticeable change seems to take place approximately in the 16th century onwards, when the traditional claims of the adepts to possess the PS were complemented by public exhibitions showing the transmuting power of their material. In some cases, the adept himself, i.e., the individual who succeeded in making the transmuting substance, carried out the transmutation

experience before a select audience, which often consisted of no more than one or two persons. However, more frequently those individuals who were in possession of the PS by often obscure and even fraudulent means used to waste such a precious material by multiplying the public exhibitions, usually fuelled by the desire to gain privilege and nobility.

Regardless, such public transmutation events spread throughout the 17th century, peaking at its last quarter, to become more scarce at the turn of the century and practically disappear by the middle of the 18th century.

These alchemical activities have left behind two kinds of records. First, there are a number of reports in the contemporary alchemical literature. Many of them are coloured by so vivid descriptions of the process, and contain such valuable details given by well-credited witnesses, as to conform a specific subclass within the alchemical literature.¹ Second, the noble metal obtained from the transmutation experience, either silver or gold, was used in some cases to cast coins or medals to commemorate a momentous event. This was done almost exclusively for transmutations performed for nobility, or the Emperors Ferdinand III and Leopold I, in Central Europe.² Some of these medals and coins have been preserved until present in several museum collections,³ whereas some other notorious examples have been lost.⁴ In few cases, pieces of silver and gold of alchemical origin survived some time after the transmutation took place, usually kept in private hands, but as far as I know their traces in history vanished long ago.⁵

Some of the extant alchemical coins and medals have been subjected to chemical analysis to assess their composition, and a few among them turned out to be composed of nearly pure silver or gold.⁶

Whereas these “fossil” remains of old alchemical activities merit a place in the history of numismatics, far less obvious is their contribution to the understanding of the alchemy itself, not to mention the alleged alchemical process in which they were obtained. For instance, as it is pointed out in reference 3, it is extremely difficult to connect unambiguously a given piece of purported alchemical origin with a specific account of transmutation event.

A closer examination of the means alleged to produce the noble metals that were used to cast medals and coins allows one to distinguish between different types of transmutations, a key aspect relevant to the present work. They can be divided in a simplified manner into two groups, according to the performance of the transmuting substance and the way to use it in order to change the base metals into noble ones.

According to the alchemical authors, the universal transmutation takes place by means of the PS or Universal Medicine, a substance claimed to change any base metal into gold. A less perfect version of this material would lead only to silver. A very small portion of this substance added or “projected” upon a melted metal or hot mercury is able to convert it into pure gold or silver, in relatively short time, not exceeding in general one hour, or a few minutes in most reports. This is the transmutation by projection. In contrast to this universal

transmutation, particular transmutations are carried out by using some liquid or solid substances which can change either one, a few base metals or only silver into gold, in a proportion not higher than five times or so its own weight. Indeed, the *particularia* (the transmuting substance) is usually not projected but digested or mixed with the base metal, rendering gold or silver after prolonged heating.⁷

The most outstanding transmutation stories that became of public domain, and went shortly after into print during the 17th and 18th centuries, took place by using the PS. This type of universal transmutation by projection will be the subject of this paper.

As expected, such public events have invariably led to strong controversy. By using a large variety of tricks, which have been reported in detail,⁸ accusations of forgery were thrown on the alchemists, who were charged of fraud to the witness yet were often learned and even leading figures in natural philosophy. The contemporary development of modern chemistry gives a scientific basis to such forgery accusations. In this context, the few alleged alchemical transmutations made or witnessed by well-known and reputed personalities where no signs of fraud could ever be found were and actually are considered “closed” historical reports; the absence of independent sources to confirm the claims make further insight into them impossible.

Could these centuries-old alchemical transmutation records be revisited by using tools other than historical ones? Could these records be analysed starting from modern scientific thought in a way other than dismissing them all as the ingenuous but nevertheless condemnable early fruits of human hopes? The present work intends to give a positive answer to this question by looking for patterns in the transmutations described in the old alchemical literature. The eventual discovery that specific characteristics of the transmutation events clustered around a given pattern would shed new light on the alchemical practices. A scientific approach in the search for such an activity pattern is presented in this paper.

Methodology

The approach that will be developed is based on quantitative aspects of the transmutation events. The qualitative characteristics are by themselves rather vague to sustain any study, although they could be valid in a more general context.

Which are the main available numerical parameters of a transmutation by projection? Typically, a certain amount (W_{PS}) of the PS is added to a certain amount of a base metal, M_i , having a weight of W_i , contained in a crucible heated at a temperature T . After a certain period of time (t), the crucible is cooled, and its content is removed, identified and weighed (M_f , W_f). Usually there is no measurement of the reaction temperature T , which is at the best indicated as “boiling quicksilver”, “melted lead” and so on. Therefore, six

independent parameters could be used: W_{PS} , M_i , W_i , M_f , W_f and t . The parameters M_i and M_f are the atomic numbers of the initial and final metals, respectively. In some cases, the metal resulting from the transmutation is submitted to analysis to determine its content of noble metal, which may eventually differ from the initial base metal weight.

From a survey of the extant reports on projection it can be concluded that in very few events the six parameters are properly measured. As expected, the starting base metal is with almost no exception, always identified, as well as the resulting gold or silver, so M_i and M_f are known. Occasionally, mixtures of several metals were also used.

Next in certitude, yet ranking well below, lies the knowledge of the weight of the metals involved in the transmutation. In some examples, only the weight of the base metal W_i or the resulting gold or silver W_f is determined. However, the greatest difficulty in studying the quantitative aspects of the transmutations described in the extant reports on these events resides in the uncertainty in the determination of the weight of the PS and the duration of the transmutation experience. In most cases, the use of very small portions of such precious material is reported, but no precise measurement of its weight is given.

Taking into account all these characteristics, few of the recorded transmutation events contain a clear indication of the values of the six parameters. I have identified a set of eight different transmutation events which meet the requirement described, to which new examples could eventually be added as a result of a more exhaustive screening of the alchemical literature.

Activity Pattern of Projections

The selected events have been collected in Table 1, together with their corresponding characteristics. These events belong to the 17th (5 events), 18th (2 events) and 19th (1 event) centuries.

It can be seen in Table 1 that the duration of the transmutation experiences spread over a large interval, ranging from what is described as instantaneous, as in the case of Van Helmont, to several hours. Among the examples listed in the table, the PS used in the experience witnessed by Van Helmont⁹ possesses the highest efficiency, which is manifested in what he describes as an “instantaneous” change of mercury into gold. This change is perceived by the observer as a “solidification” of the content of the crucible, due to the difference between the temperature of the hot mercury, which should be below its boiling point (357 °C) and the melting point of pure gold (1,063 °C).

On the other hand, variations of several orders of magnitude of the weight ratio between the resulting noble metal and the PS (W_f / W_{PS}), which is defined as its transmuting power, are also recorded. Both sets of data, time and transmuting power, have been plotted in Figure 1, where it can be observed that they follow an inverse correlation. The trend indicates that in the transmutation

TABLE 1
 Characteristics of Alchemical Transmutations

Example	Year	Reference name	Type of transmutation	W_i	W_f	W_{PS}	W_f/W_{PS}	Time (min)	Ref.
1	1614	Van Helmont	Hg → Au	8 ounces	8 ounces less 11 grains	¼ of grain	19,186	Inst. (<1 min)	9
2	1667	Helvetius	Pb → Au	6 dracmas	6 dracmas plus 6 scrupules	0.020-0.040 grams	700-1,400	15	11
3	1675	Seyler?	Sn → Au	—	8 ounces	—	2,000	5-7	10
4	1678	Boyle	Pb → Au	Several dracmas	≥½ ounce	1-2 grains	Several hundred 200-500	15	12
5	1693	C. Eisenberg	Pb → Ag	1.5 pound	37 lothons	32 grains	325	60-70	13
6	1716	Goetzius	Cu → Ag	—	—	—	6,552	2-5	14
7	1717	Colonna	Hg → Au	2 ounces	~2 ounces	0.5-0.6 grains	2,000-2,400	120	15
8	1832	Cyliani	Hg → Au	100 grams	100 grams	1 gram	100	60	16

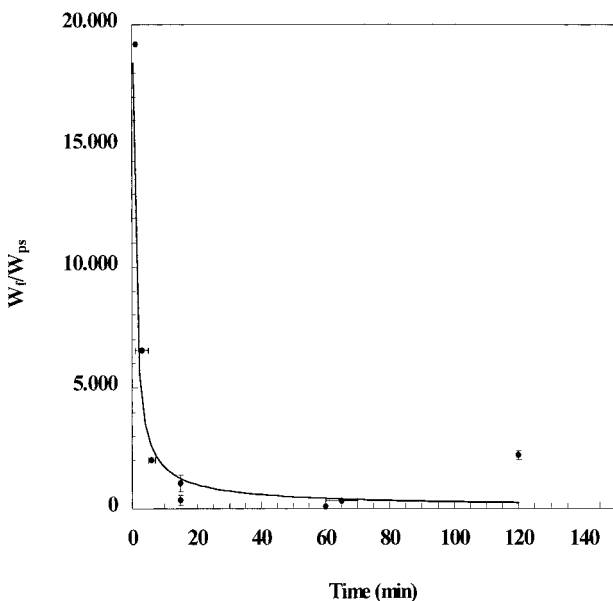


Fig. 1. Transmuting power (W_f/W_{ps}) as a function of the transmutation time.

events where the transmuting power value is no more than a few hundred, heating of the base metal and the PS mixture should be kept for at least twenty minutes before completion. Conversely, in those experiences where the PS manifested a power of several thousand, a few minutes are required to complete the transmutation. It is interesting to notice that the transmutation witnessed by Robert Boyle, which only very recently has been exposed to general knowledge and analysed in reference 7, also fits nicely the general trend shown by the other more widely known experiences.

To the best of my knowledge such an activity pattern has not been noticed. However, the need for prolonged heating when samples of the PS having low transmuting power are used is mentioned in an interview Boyle conducted with a visitor from Vienna, who described projections carried out at the imperial court of Leopold I¹⁰:

... he told me he saw an other time a projection made on the same metal (tin) with an imperfect Medicine, which was longer in working before it effected the desire change, & transmuted but (if I mistake not) about 80 times its own weight.

The activity pattern described in Figure 1 can hardly be the result of a hypothetical stoichiometric reaction between the PS and the base metal, owing to the disparity in their relative weights. On the contrary, it could be understood in the frame of a sort of catalytic reaction where the PS would be the catalyst. In catalysis science, the ability of different chemical substances to catalyse a given chemical reaction is usually compared on the basis of the time required to

transform a given amount of the initial reactants into products. Highly efficient catalysts lead to high reaction rates, and are usually able to transform a large amount of the starting reagents before its activity begins to decline in a significant manner. Indeed, as the catalytic activity of a given chemical substance is improved, a smaller amount of such a substance is required to obtain high reaction rates.

By following this catalytic approach it could be thought that even the smallest portion of a catalyst would be able to transform any quantity of the starting chemical compounds provided the reaction time is sufficiently long. However, this is not the case with real catalysts. Materials having poor catalytic performance or good catalysts used in an excessively low amount, i.e., at a large reactant-to-catalyst ratio, never bring to completion the targeted reaction, as usually the catalyst transforms slowly into an inactive substance or is deactivated or “poisoned” by undesired by-products. For this reason, the maximum reactant to catalyst working ratio should be properly adjusted for every catalytic material.

Interestingly, the existence of an upper limit for the transmuting power of the PS has also been described in the alchemical literature. For instance, the anonymous visitor of Helvetius remarks the following, as it is accounted in his “*Vitulus Aureus*”¹¹:

If you are not able to deal with such a small amount of lead (four grains) take two dracmas, or half ounce, or even more lead, for it will not be tinged more than it could be. [“Tinged” refers to the induced alchemical change which observers detect by change in colour.]

The alchemical transmutation process has been conceived as an acceleration of the ripening of base metals towards the more perfect gold and silver by authors prone to an alchemical conception of nature, such as Johan Joachim Becher.² Apparently, this is one of the first theoretical manifestations, however embryonic, of the notion of catalytic action of chemical substances.

The relationship between the transmutation time and the transmuting power could eventually be affected by the nature of the resulting noble metal, either gold or silver, or even by the starting base metal. Indeed, some indications of this influence can already be tracked in the alchemical literature. For instance, the anonymous owner of the PS referred to by François-Marie Pompée Colonna states that the change of mercury into silver required only a quarter of an hour, instead of the two hours needed to transmute it into gold.¹⁵ Therefore, further improvement of the relationship would result by analysing both reactions independently.

The accordance of the alchemists’ manipulations to this pattern, if confirmed by examination of further new evidence, would shed new light on the past alchemical practices and their theoretical context.

Notes

¹ Ewald von Høghelande, *Historiae aliquot transmutationis Metallicae*, (Cologne, 1604); Daniel George Morhof, *De metallorum transmutatione ad*

Langelottum, (Hamburg, 1673), in *Bibliotheca Chemica Curiosa (B.C.C.)*, (Geneva, 1702), vol. 1, p. 168; Johann Friedrich Helvetius, *Vitulus Aureus* (Amsterdam, 1667), in *B.C.C.*, (Geneva, 1702), vol. 1, p. 196; Philipp Jacob Sachs von Lewenheim, “Aurum Chymicum”, in *B.C.C.*, (Geneva, 1702), vol. 1, p. 192., Siegmund Heinrich Guldendalk, *Sammlung von mehr als hundert wahrhaften Transmutationsgeschichten*, (Frankfurt and Leipzig: J. G. Flesher, 1784). This is one of the biggest (and latest) collections of alchemical transmutation accounts, listing exactly 112 according to the contents.

- ² Smith, P. H. (1994). *The Business of Alchemy. Science and Culture in the Holy Roman Empire*. Princeton, NJ: Princeton University Press (pp. 173–227).
- ³ Reyher, *De nummis quibusdam ex chymico metallo factis*, (Kiel, 1692). For a more recent and comprehensive review of medals and coins of purported alchemical origin, see: Karpenko, V. (1988). Coins and medals made of alchemical metals. *Ambix*, 35, 65–76.
- ⁴ The most famous example is probably the large medal cast with alchemical gold resulting from the transmutation performed in Prague, on the 15 of January 1648, in the presence of Austrian emperor Ferdinand III. The medal has been reproduced many times in a variety of works since then, see for example Karpenko, *op. cit.* (3), p. 67.
- ⁵ There are several accounts of transmutation stories published in the 17th century where the possession of gold pieces of alchemical origin by individuals is claimed. For instance, the gold piece kept by Johannis Antonida Van der Linden was a result of the transmutation performed by Alexander Seton in 1602. Two other fragments of alchemical gold resulting from the activities of this alchemist were in the hands of Johann Wolfgang von Dienheim, professor of medicine at the University of Freiburg, and Jacob Zwinger, professor at the University of Basel. I have used the French translation of the Dienheim account given in: Figuier, L. (1856) *L'Alchimie et les Alchimistes* (2nd ed., pp. 227–228), Paris: Hachette. For a recent updated account of the Alexander Seton and Sendivogius relationship, see: Prinke, T. (1999). The twelfth adept. In White, R. (Ed.), *The Rosicrucian Enlightenment Revisited* (pp. 141–192). New York: Lindisfarne Books. In my opinion, the most notorious example of a piece of gold surviving for some years the projection has been reported by professor L. M. Principe, *The Aspiring Adept* (Princeton, NJ: Princeton University Press, 1998). In his book, professor Principe describes Boyle's witnessing of a projection and the fact that he (Boyle) always carries with him a fragment of transmuted gold (*op. cit.*, p. 105). Also mentioned in this book is a piece of silver transmuted into gold that Olaus Borrichius sent to the king of Denmark (*op. cit.*, p. 260).
- ⁶ See *op. cit.* (3) and references therein for chemical analysis of pieces of metals of alleged alchemical origin. The commemorative medallion cast from the metal obtained by J. J. Becher after transmuting lead, and housed in the Vienna Kunsthistorische Museum, is pure silver, according to W. D. Müller-Jahncke

and J. Telle, “Numismatik und Alchemie. Mitteilungen zu Münzen und Medaillen als 17. und 18. Jahrhunderts”, in *Die Alchemie in der europäischen Kultur und Wissenschafts-geschichte*, ed. Christoph. Meinel (Wiesbaden: Otto Hanassowitz, 1986), pp 251–252. This statement has been taken from *op. cit.* (2), p. 176.

⁷ For a recent and clear exposition of the different varieties of transmutations, see L.M. Principe, *The Aspiring Adept*, (Princeton, NJ: Princeton University Press, 1998), pp. 77–80.

⁸ Karpenko, V. (1992). The chemistry and metallurgy of transmutation. *Ambix*, 39, 47–62.

⁹ The transmutation witnessed by Van Helmont in 1614 is the one where the transmuting power has been determined with the highest accuracy. Johan Baptista Van Helmont (1667), *Ortus Medicinae* (4th ed., p. 452). Regarding the duration of the trial, he described it as an instantaneous “congelatium” of the quicksilver. In order to facilitate the numerical treatment of the data, a maximum duration of one minute has been safely assigned to this projection. It may seem that the duration of the projection was even shorter, for compliance with the Van Helmont description. Regardless, it will be shown later that the incertitude range of the transmuting time is much smaller than the time differences among the several transmutations reported in the table.

¹⁰ The information regarding this transmutation has been taken from *op. cit.* (7), p. 299. The person interviewed by Boyle reports the transmutation to last “half a quarter of an hour or less”. Therefore, a range of 5 to 7 minutes has been assumed in this case. Professor Principe has tentatively assigned this projection to Wenceslaus Seyler, an Augustinian monk active in the Vienna court around 1675. J. J. Becher gives a full account of Seyler’s activities in his *Magnalia Naturae*, (London, 1680).

¹¹ Helvetius, *op. cit.* (1). In the Helvetius account of his transmutation the duration of the projection is clearly stated, but no weight of the PS is given. Instead, the volume of the PS used in the projection was described as “half seed of swede” or “a quarter of mustard grain”. According to these indications, the volume of the PS has been estimated to be between 1 and 2 mm³. From this volume, the PS weight could be estimated if the density is known. There are several descriptions that emphasise that the PS is very heavy in relation to its volume, i.e., it has a high density. For instance, Karl Cristoph Schmieder, *Geschichte der Alchemie*, (Halle, 1832) provides a full account of the description given by Dippel, who in 1706 examined portions of a substance allegedly to be the PS. In Dippel’s own words, “a block of lead of the same volume would have been much less weighted”. I have assigned a density of 20 g/cm³ to the substance described by Helvetius.

¹² *Op. cit.* (7), pp. 264–267. The transmuting power of the PS is estimated by Robert Boyle to be “several hundred”. According to the reported weights of gold and the PS, a range of 200–500 for the transmuting power can be safely assumed.

- ¹³ The projection was performed before the Duke Christian Eisenberg (1653–1707). Details of this event have been taken from Husson, B. (1974). *Transmutations Alchimiques*. Paris: Editions J'ai Lu (pp. 98–101). The original account can be found in Rosinus Lentilius, *Ephemeridae medicophysicae Germanicae Curiosae*, Decuria III, Annus Tertius, Annorum 1695 and 1696, Appendix ad Annum Tertium, pp 111–112, (1696).
- ¹⁴ A full account of this transmutation is given in Husson, *op. cit.* (13), pp. 107–115. This is a French translation of the original Latin version reported by Johann Christoph Goetzius. *Commercium Litterarium ad rei medicae et scientiae naturalis incrementum institutum*, n° 43 (1731). In this example, two copper coins, one of them a Vienna Polture from 1707, were transmuted into silver. The coins were heated at high temperature (one of the coins shows signs of melting after the experience) but not melted. The PS was then put in contact for a short time over the hot coin surface. No precise measurement of the transmutation time is provided in the account, but it is nevertheless reported that after the surface contact with the PS the coins were dipped into water for cooling. The first coin remained in water for such a short time that it was still hot when extracted from the water recipient. Taking this observation into account, it has been assumed that the total duration of the experience could not have been longer than a few minutes. Therefore, an interval from 2 to 5 minutes has been assigned to this event. The weight of the PS, coins and silver resulting from the experience were measured, and as a result a transmuting power of 6,552 is obtained. This high transmuting power approaches this experience to the transmutations by projection.
- ¹⁵ de la Haumerie, C. (1722). *Les secrets les plus cachés de la Philosophie des Anciennes*. Paris. For a more recent French version, see Husson, *op. cit.* (13), pp. 254–255.
- ¹⁶ Cyliani (1832). *Hermès Dévoilé*. Paris: Félix Locquin. For a more recent French edition, see Husson, B. (1988). *Deux Traités Alchimiques du XIX Siècle*. Paris: Editions La Table d'Émeraude (pp. 203–233).