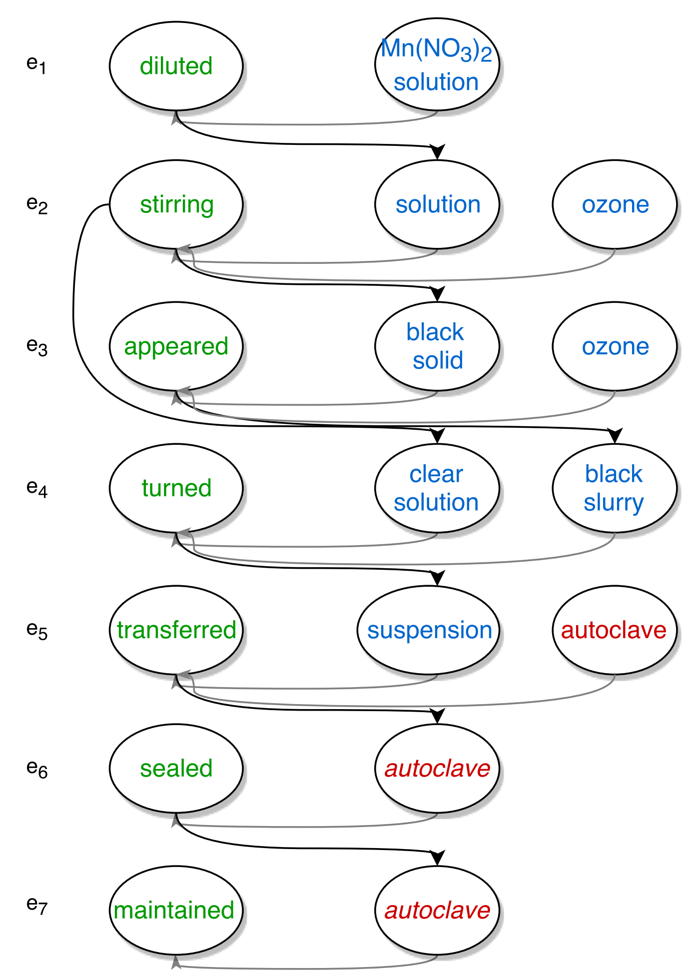
Automatically Extracting Action Graphs From Materials Science Synthesis Procedures

Sheshera Mysore
Edward Kim
Emma Strubell
Ao Liu
Haw-Shiuan Chang
Srikrishna Kompella
Kevin Huang
Andrew McCallum
Elsa Olivetti

Typical synthesis procedure text

In a typical procedure for the synthesis of β-MnO_2 nanowires, 2.5 mL of 50 wt.% $Mn(NO_3)_2$ solution was diluted to 25.0 mL, and ozone was fed into the bottom of the solution for 30 min under vigorous stirring. With the indraught of ozone, black solid appeared gradually and the clear solution turned into black slurry finally. Then the suspension was transferred into an autoclave of 48.0 mL, sealed and maintained at 200 °C for 8 h. After this, the autoclave was cooled to room temperature naturally. The resulting solid products were washed with water, and dried at 120 °C for 8 h.



UMassAmherst
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Goal: automatically extract materials synthesis procedures from text.

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- Want to accelerate materials science via large-scale analysis, prediction of inorganic synthesis routes

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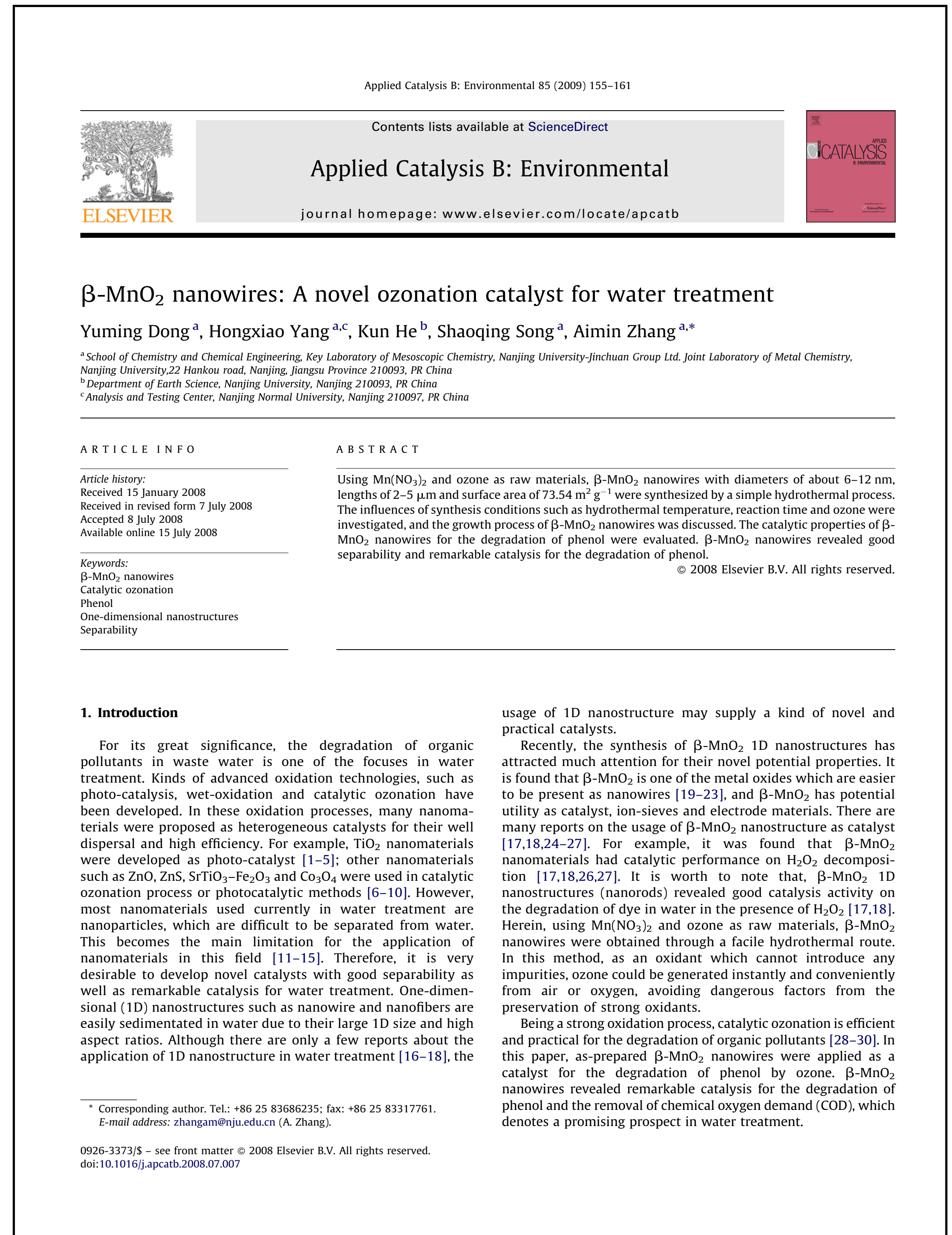

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β-MnO_2 nanowires: A novel ozonation catalyst for water treatment

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A R T I C L E I N F O

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Separability

A B S T R A C T

Using $Mn(NO_3)_2$ and ozone as raw materials, β-MnO_2 nanowires with diameters of about 6–12 nm, lengths of 2–5 μm and surface area of 73.54 $m^2\ g^{-1}$ were synthesized by a simple hydrothermal process. The influences of synthesis conditions such as hydrothermal temperature, reaction time and ozone were investigated, and the growth process of β-MnO_2 nanowires was discussed. The catalytic properties of β-MnO_2 nanowires for the degradation of phenol were evaluated. β-MnO_2 nanowires revealed good separability and remarkable catalysis for the degradation of phenol.

1. Introduction

For its great significance, the degradation of organic pollutants in waste water is one of the focuses in water treatment. Kinds of advanced oxidation technologies, such as photo-catalysis, wet-oxidation and catalytic ozonation have been developed. In these oxidation processes, many nanomaterials were proposed as heterogeneous catalysts for their well dispersal and high efficiency. For example, TiO_2 nanomaterials were developed as photo-catalyst [1–5]; other nanomaterials such as ZnO, ZnS, $SrTiO_3$–Fe_2O_3 and Co_3O_4 were used in catalytic ozonation process or photocatalytic methods [6–10]. However, most nanomaterials used currently in water treatment are nanoparticles, which are difficult to be separated from water. This becomes the main limitation for the application of nanomaterials in this field [11–15]. Therefore, it is very desirable to develop novel catalysts with good separability as well as remarkable catalysis for water treatment. One-dimensional (1D) nanostructures such as nanowire and nanofibers are easily sedimentated in water due to their large 1D size and high aspect ratios. Although there are only a few reports about the application of 1D nanostructure in water treatment [16–18], the usage of 1D nanostructure may supply a kind of novel and practical catalysts.

Recently, the synthesis of β-MnO_2 1D nanostructures has attracted much attention for their novel potential properties. It is found that β-MnO_2 is one of the metal oxides which are easier to be present as nanowires [19–23], and β-MnO_2 has potential utility as catalyst, ion-sieves and electrode materials. There are many reports on the usage of β-MnO_2 nanostructure as catalyst [17,18,24–27]. For example, it was found that β-MnO_2 nanomaterials had catalytic performance on H_2O_2 decomposition [17,18,26,27]. It is worth to note that, β-MnO_2 1D nanostructures (nanorods) revealed good catalysis activity on the degradation of dye in water in the presence of H_2O_2 [17,18]. Herein, using $Mn(NO_3)_2$ and ozone as raw materials, β-MnO_2 nanowires were obtained through a facile hydrothermal route. In this method, as an oxidant which cannot introduce any impurities, ozone could be generated instantly and conveniently from air or oxygen, avoiding dangerous factors from the preservation of strong oxidants.

Being a strong oxidation process, catalytic ozonation is efficient and practical for the degradation of organic pollutants [28–30]. In this paper, as-prepared β-MnO_2 nanowires were applied as a catalyst for the degradation of phenol by ozone. β-MnO_2 nanowires revealed remarkable catalysis for the degradation of phenol and the removal of chemical oxygen demand (COD), which denotes a promising prospect in water treatment.

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ELSEVIER

2. Experimental

2.1. Materials and preparation

All chemicals were of analytical grade and were used as received without further purification. The water used throughout was distilled water. Ozone was generated in a laboratory ozone generator from pure oxygen, and the flow rate of ozone was 0.30 mg min^{-1}.

In a typical procedure for the synthesis of β-MnO_2 nanowires, 2.5 mL of 50 wt.% $Mn(NO_3)_2$ solution was diluted to 25.0 mL, and ozone was fed into the bottom of the solution for 30 min under vigorous stirring. With the indraught of ozone, black solid appeared gradually and the clear solution turned into black slurry finally. Then the suspension was transferred into an autoclave of 48.0 mL, sealed and maintained at 200 °C for 8 h. After this, the autoclave was cooled to room temperature naturally. The resulting solid products were washed with water, and dried at 120 °C for 8 h. The obtained products were collected for the following characterization.

For comparison of catalysis activity, we also synthesized β-MnO_2 nanowires and dandelion-like β-MnO_2 microstructures according to literatures [20,31]. The β-MnO_2 bulk phase material and TiO_2 nanoparticles (P25) used were from commercial sources.

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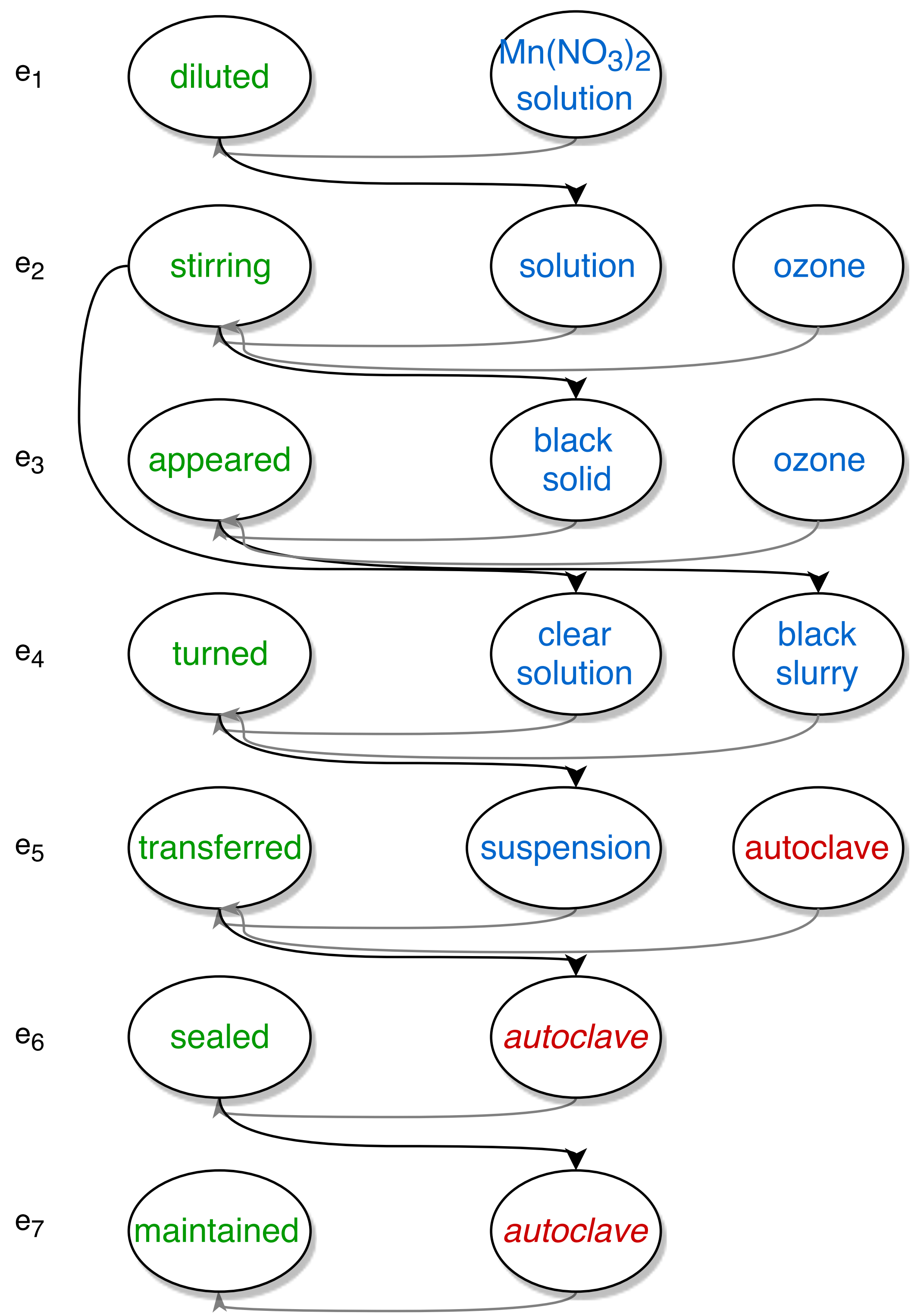

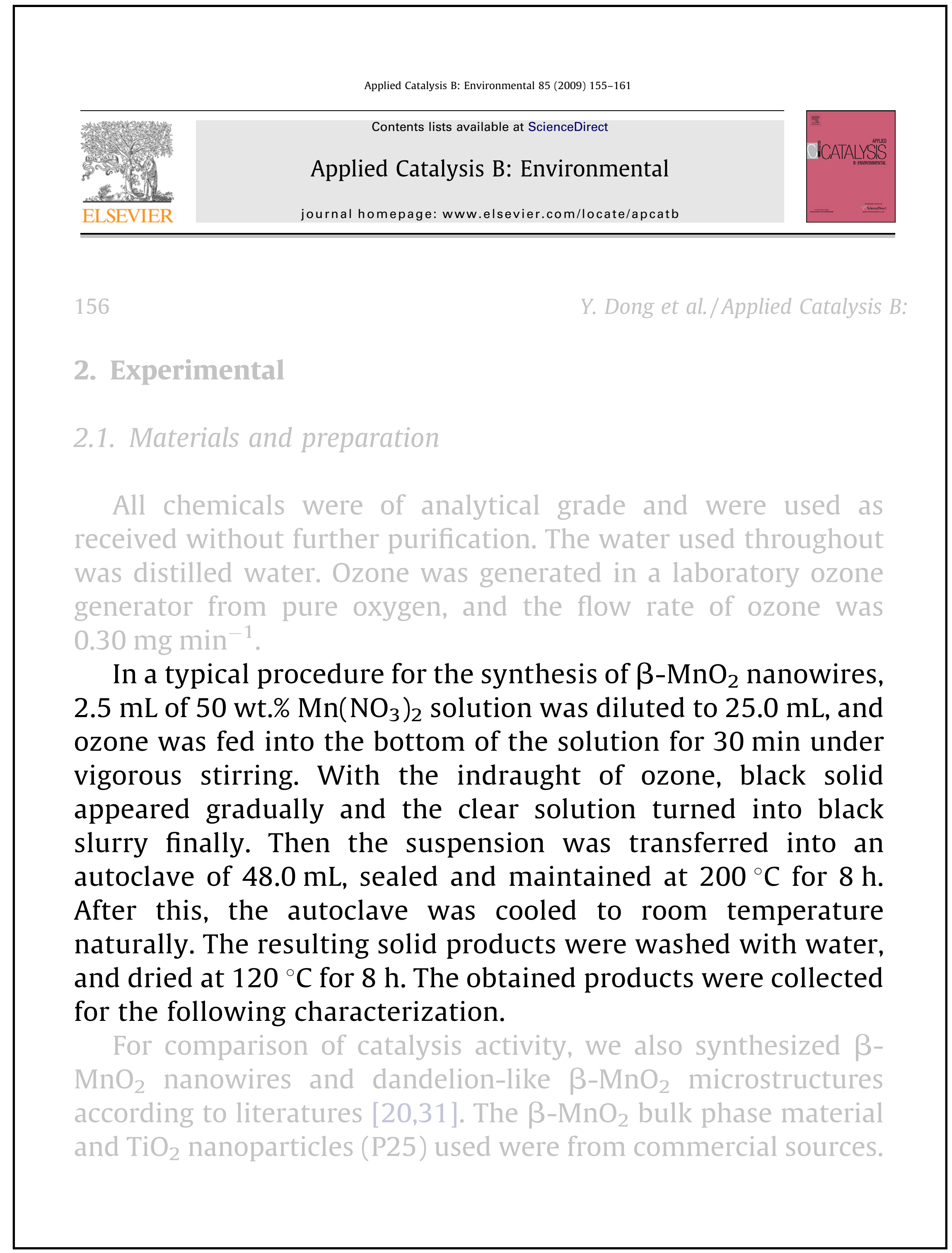

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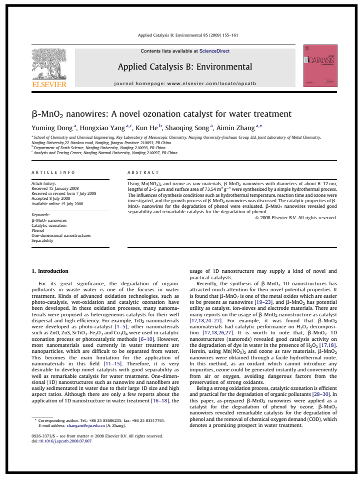
Overall pipeline architecture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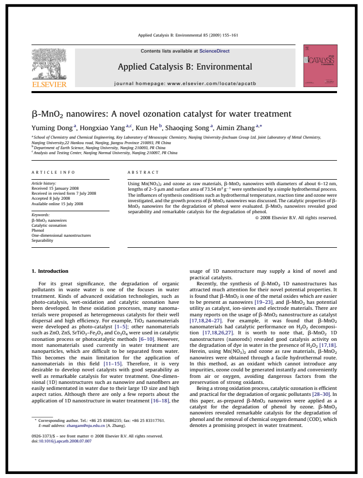
Applied Catalysis B: Environmental

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PDF to text →

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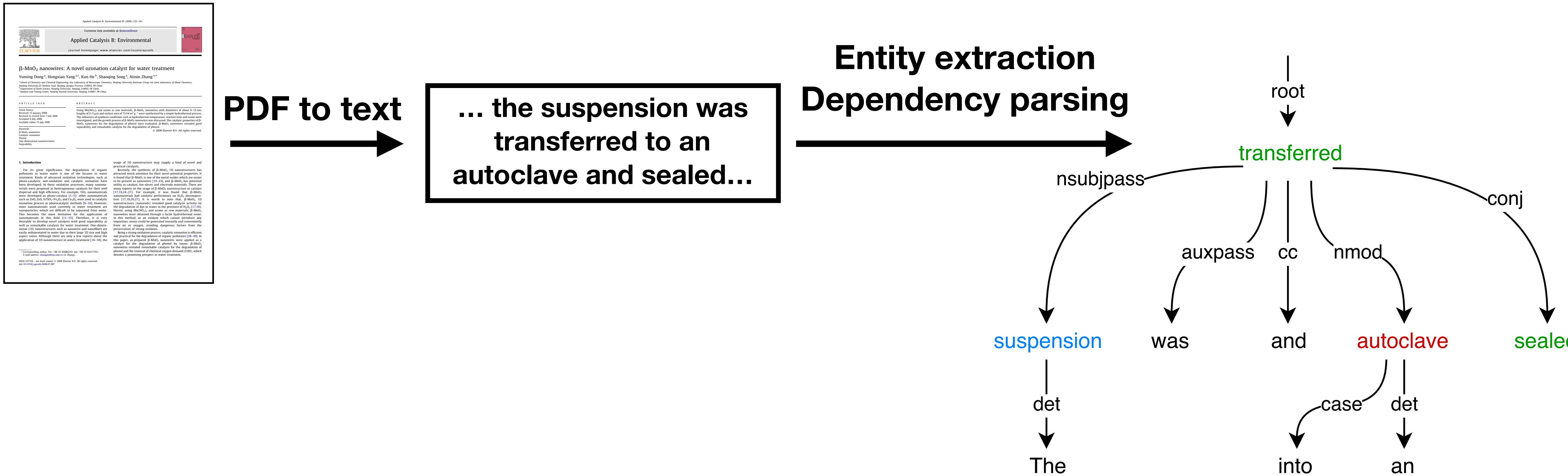

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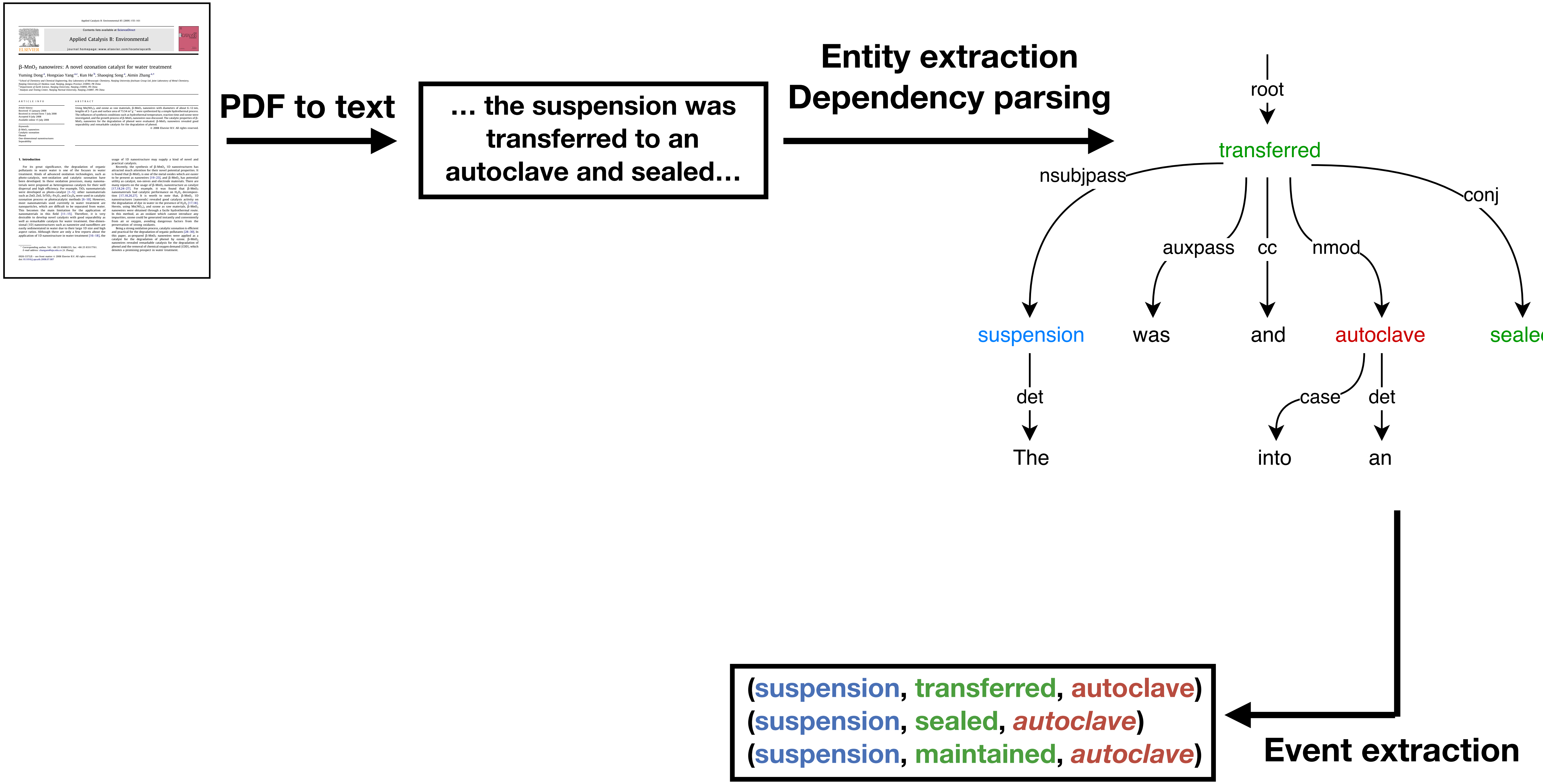

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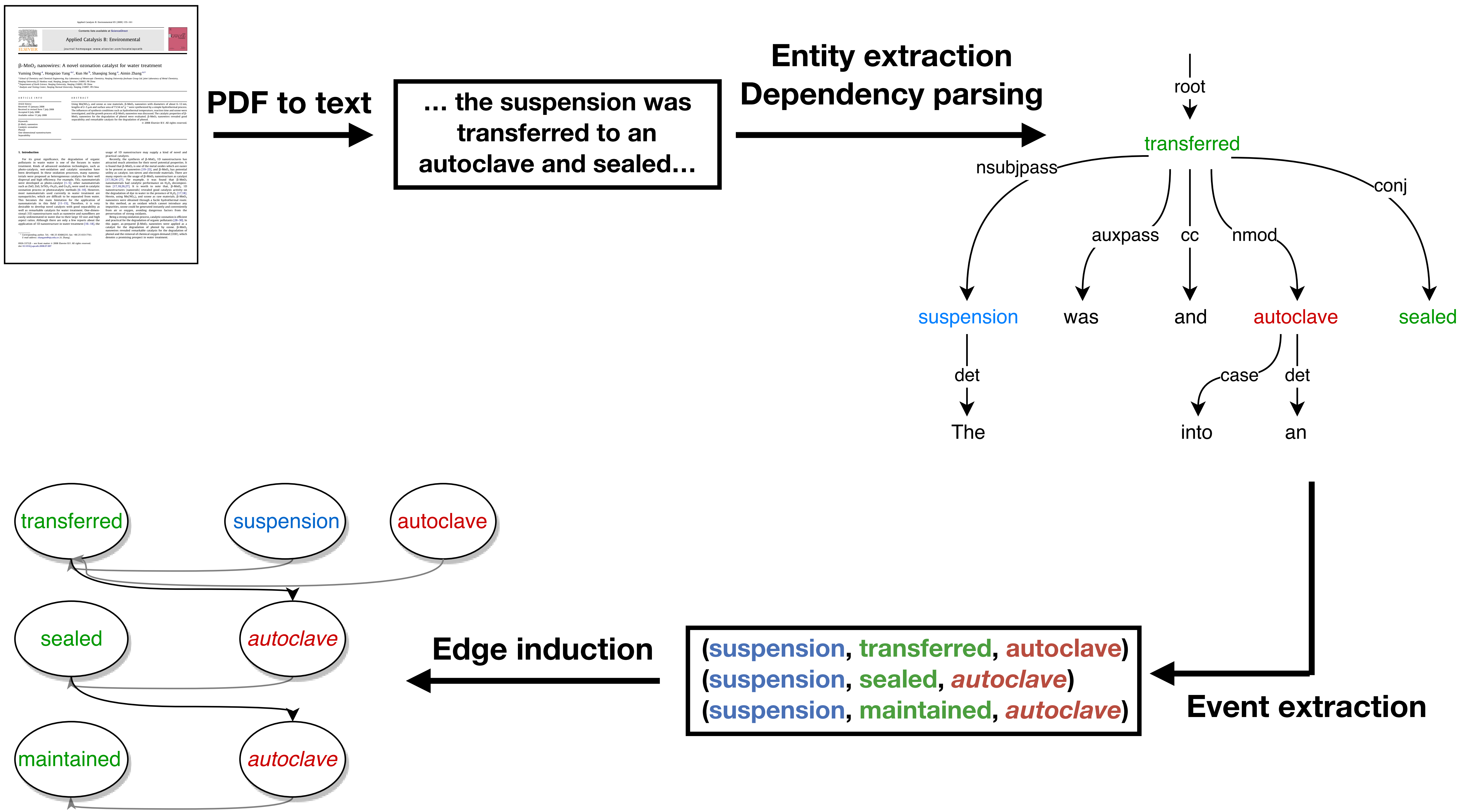

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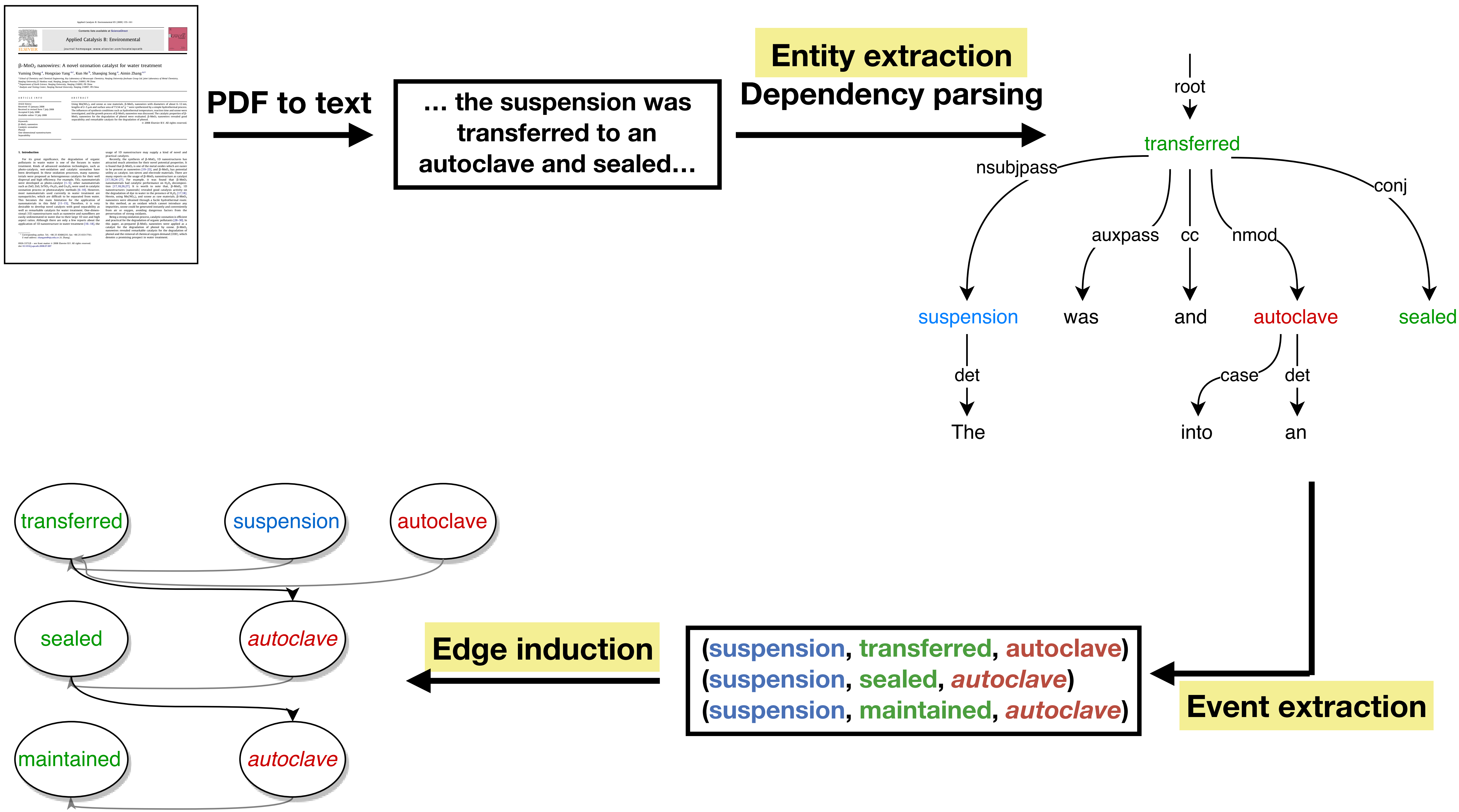

Entity extraction

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→

MATERIAL OPERATION APPARATUS OPERATION

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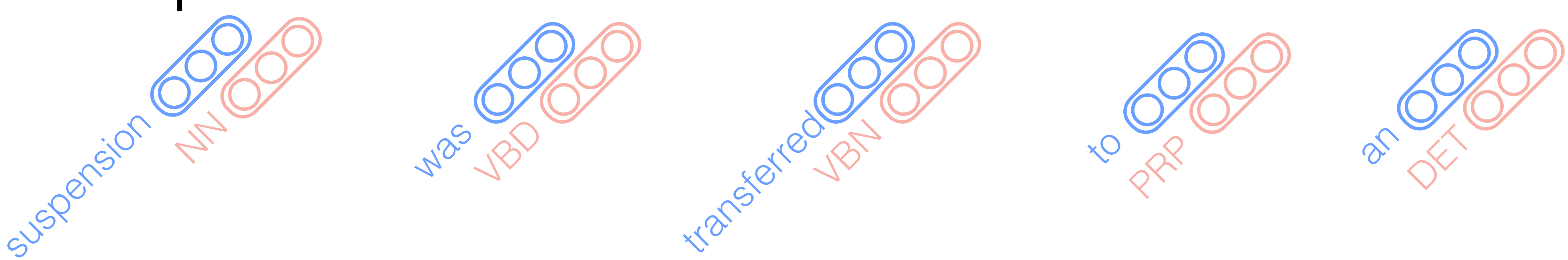
... suspension was transferred to an ...



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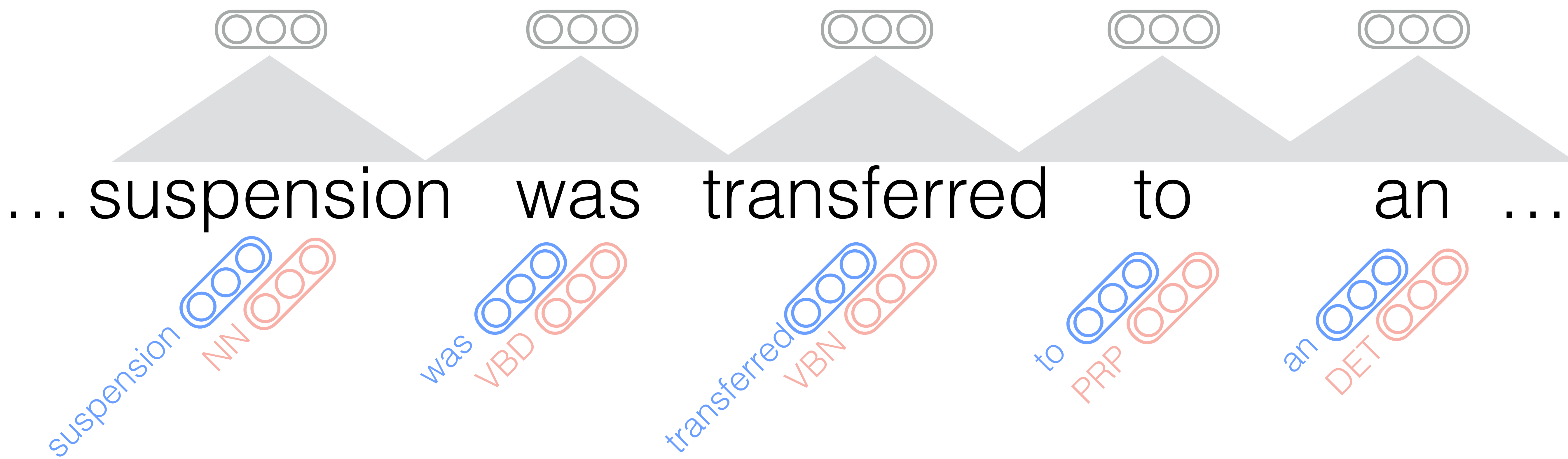

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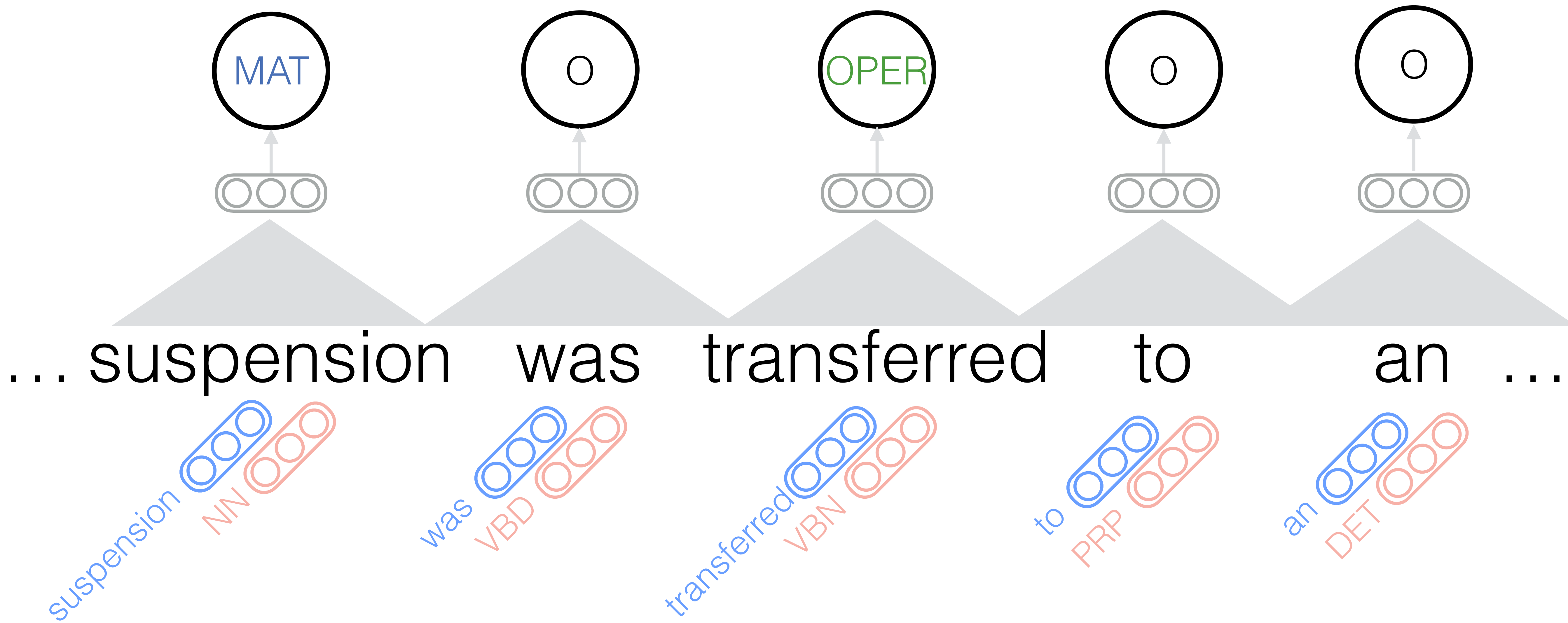

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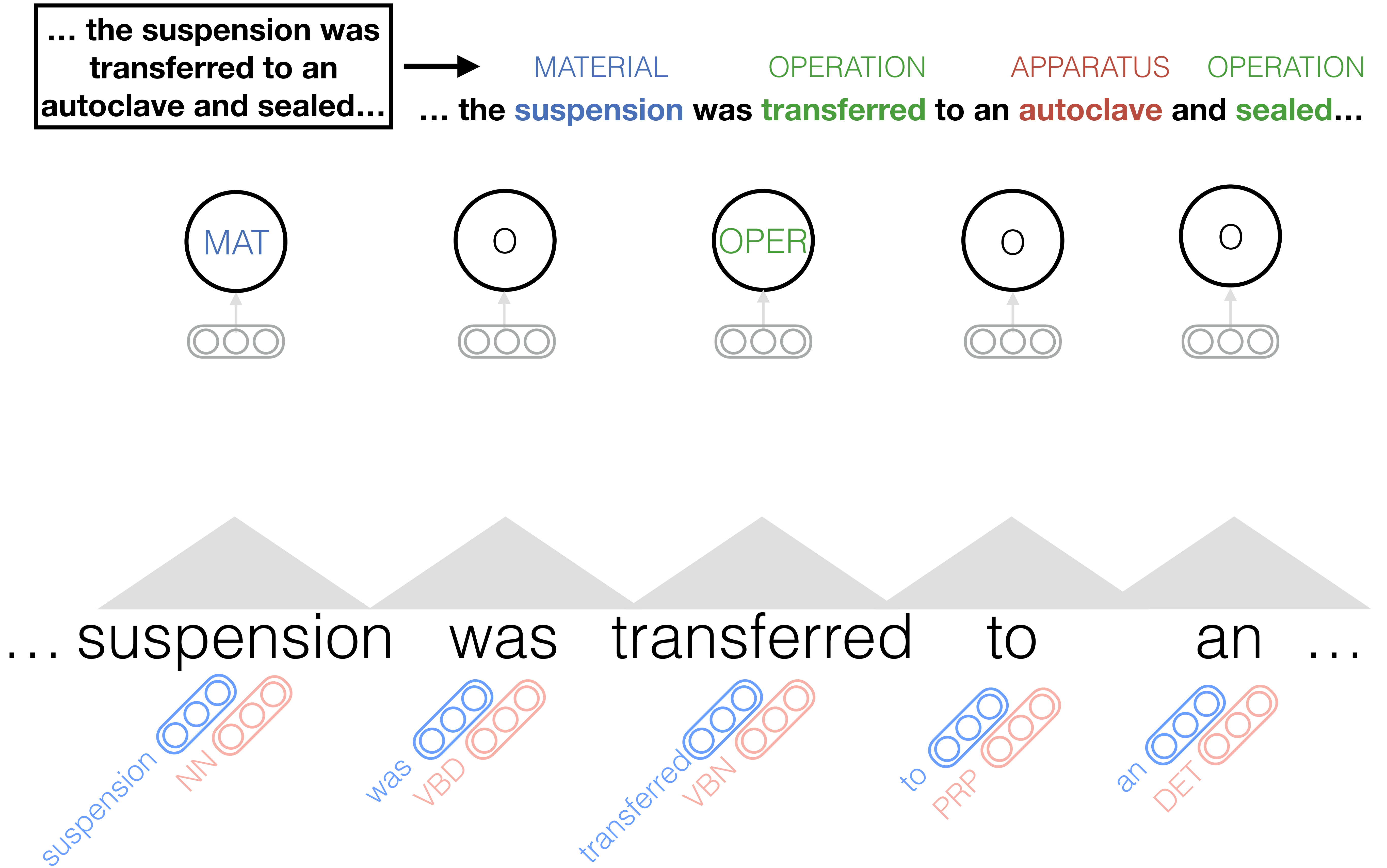

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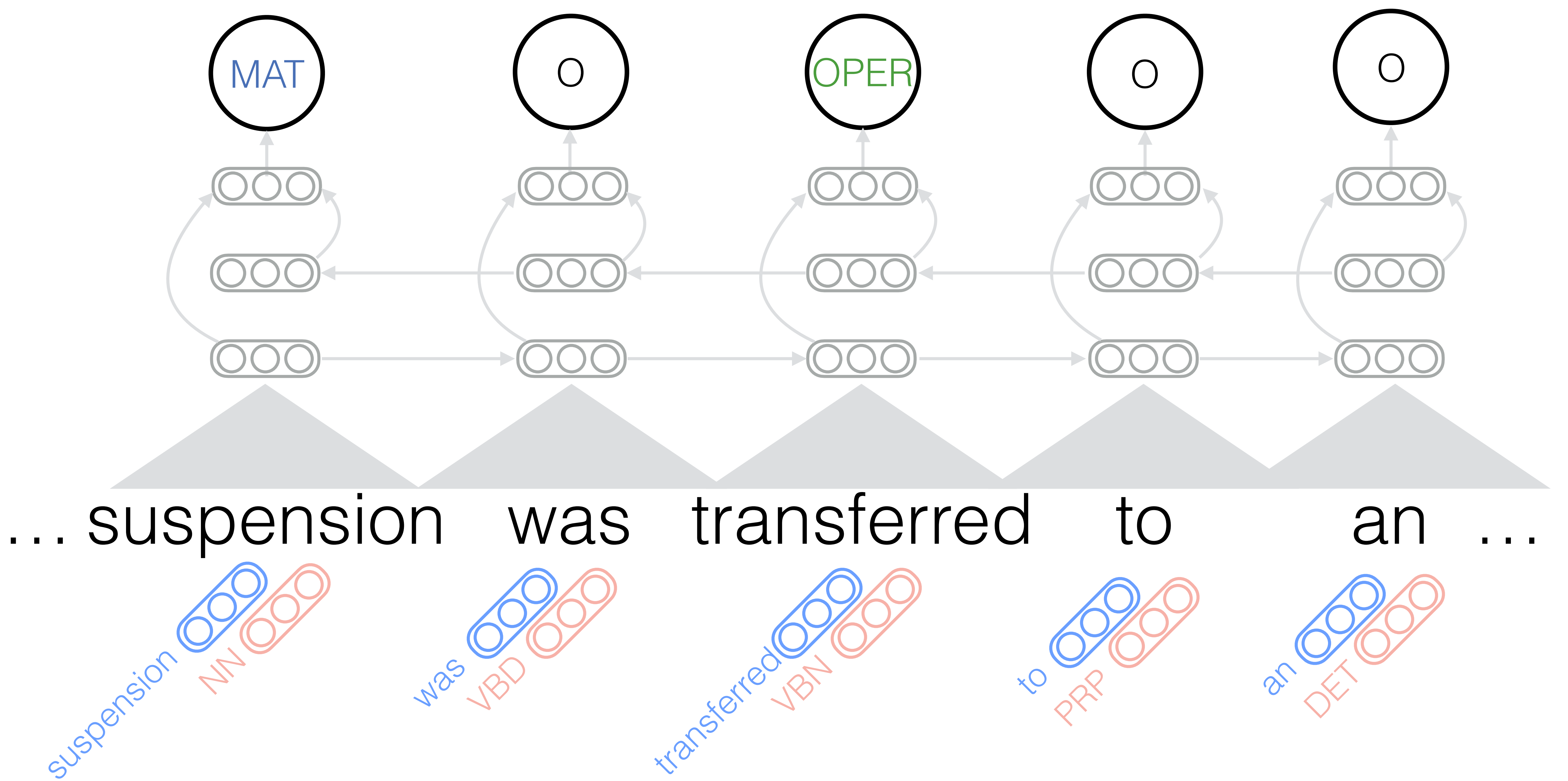

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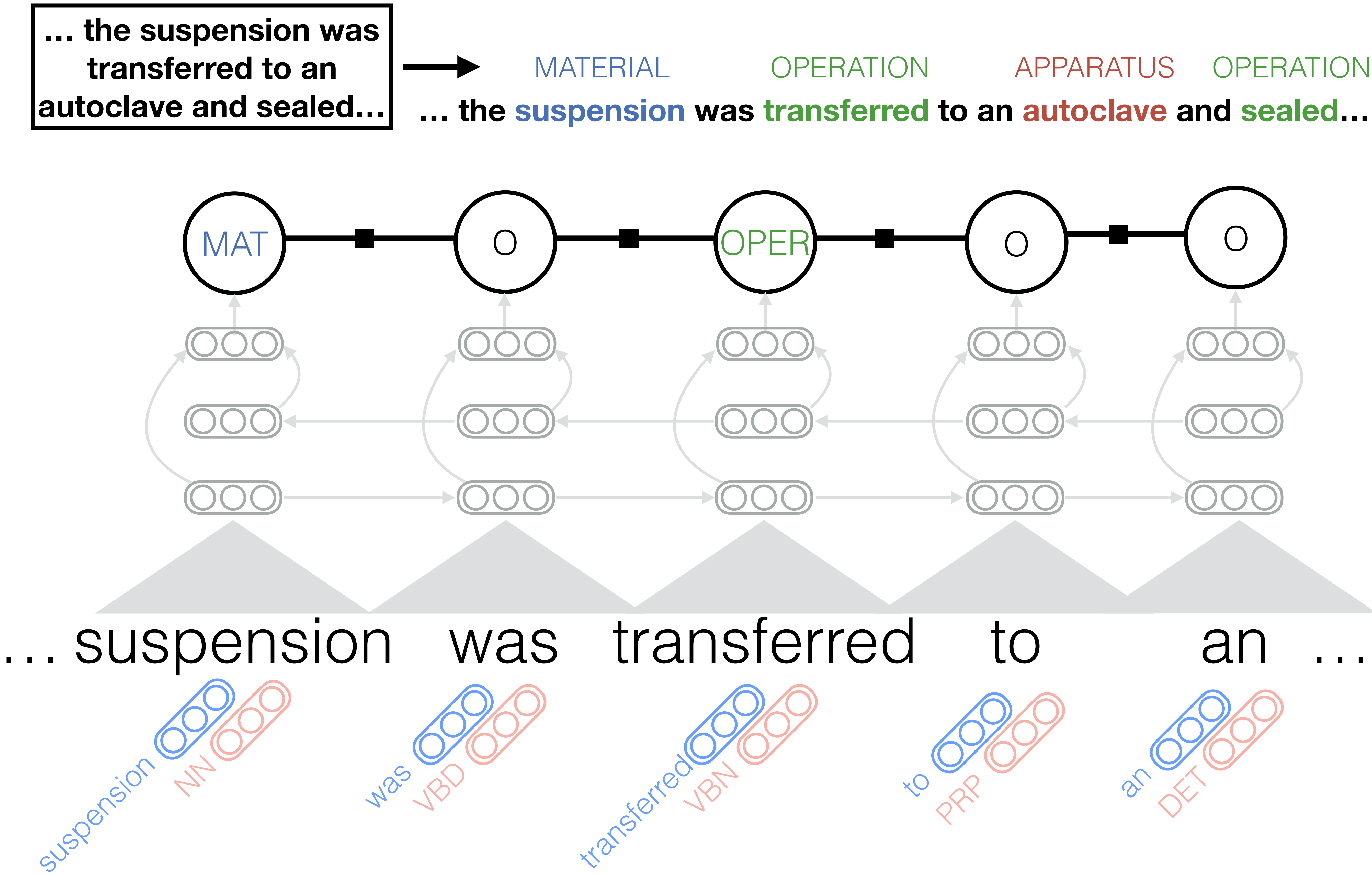
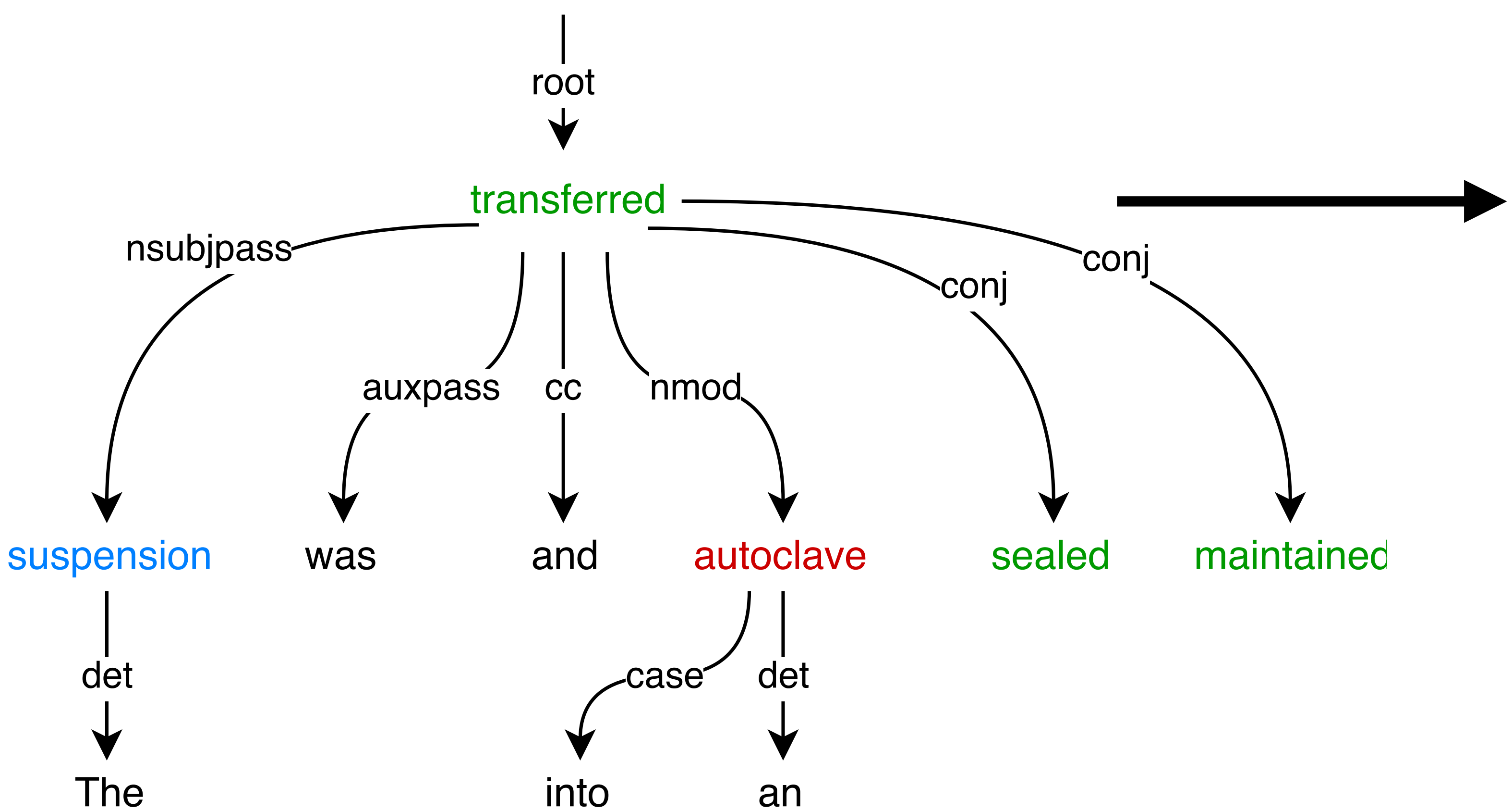


Event extraction

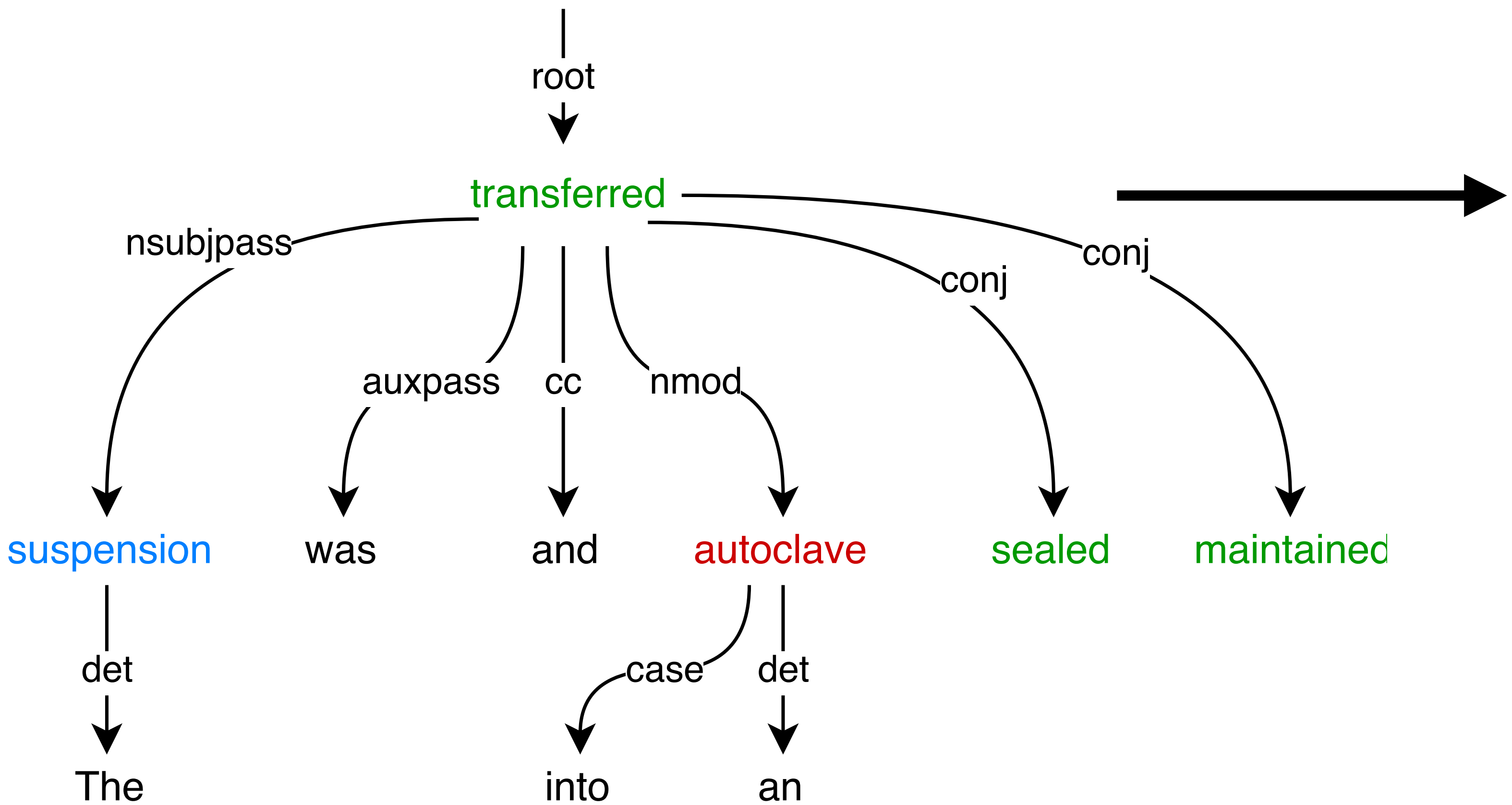
Event extraction



(suspension, transferred, autoclave)
(suspension, sealed, *autoclave*)
(suspension, maintained, *autoclave*)

Event extraction

- Rules over dependency parse tree + entities



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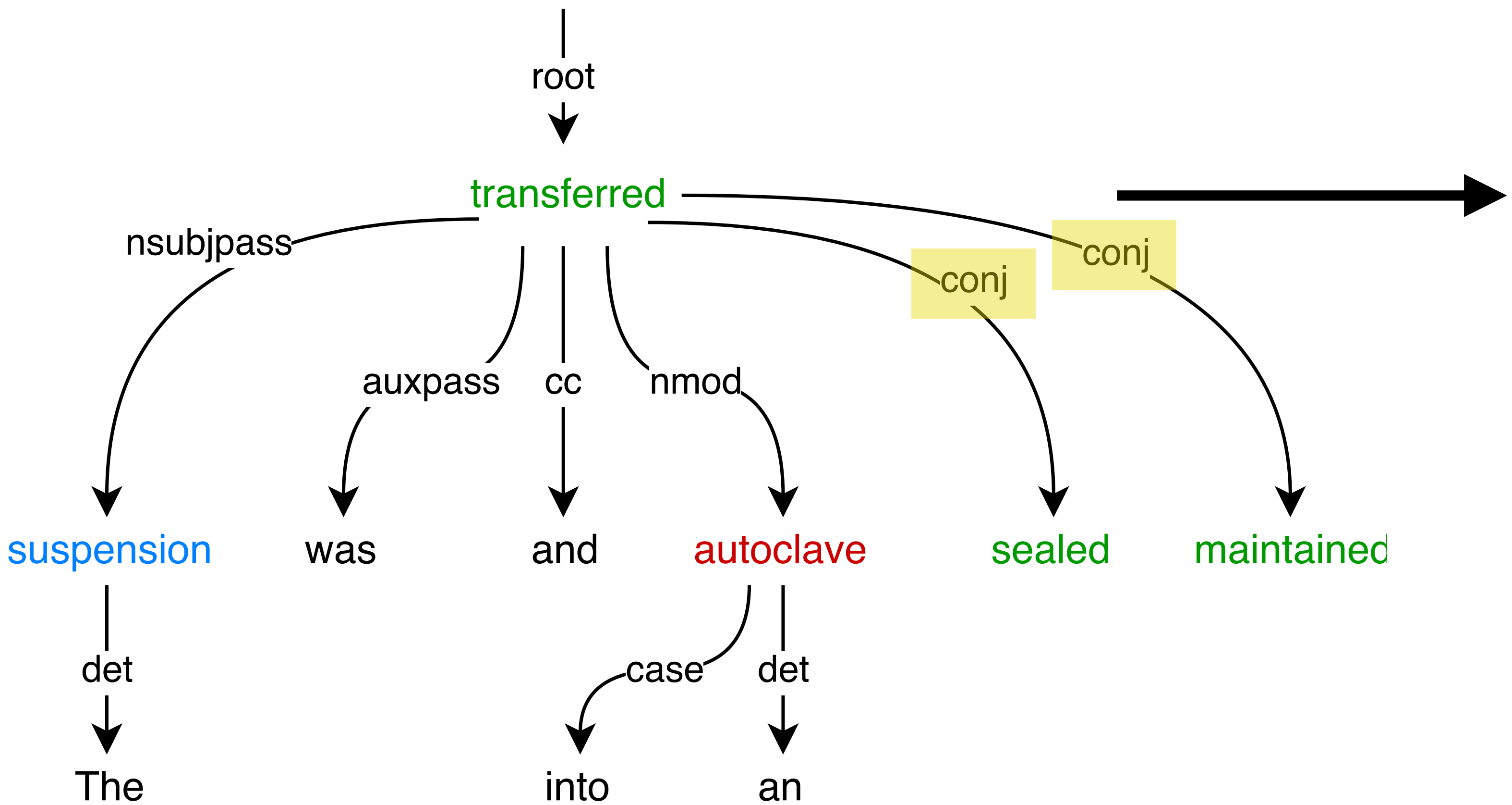

(**suspension**, **transferred**, **autoclave**)
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Edge induction

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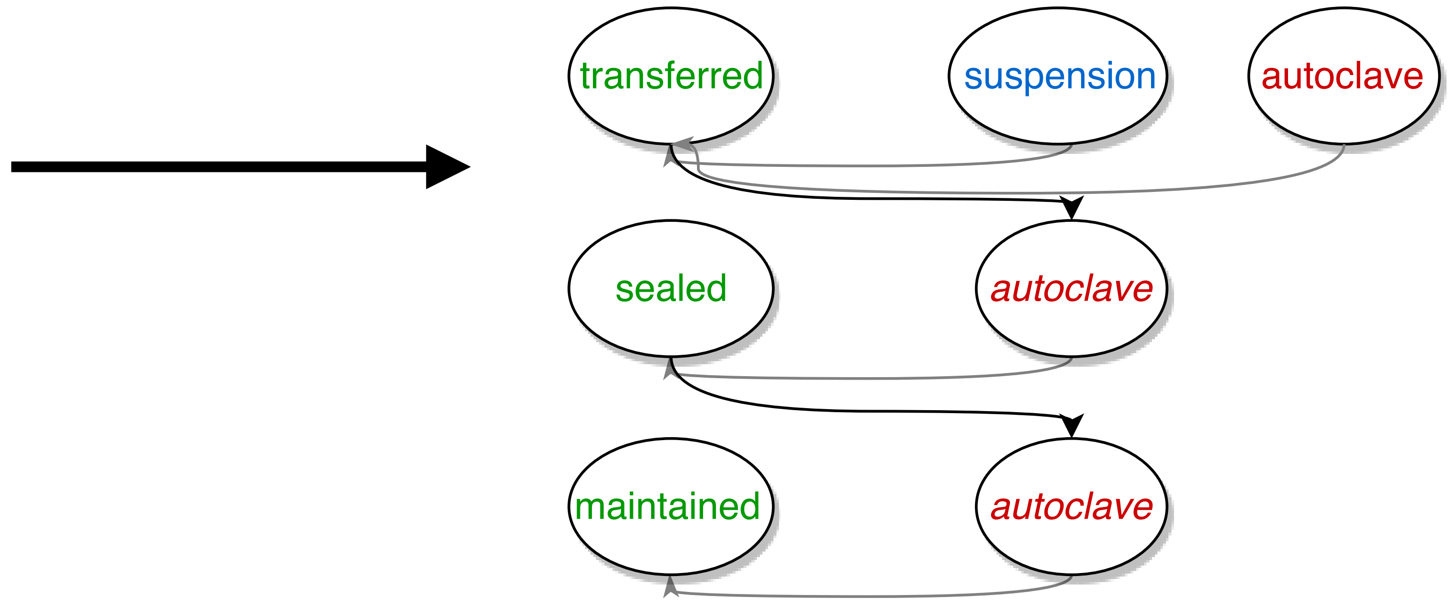

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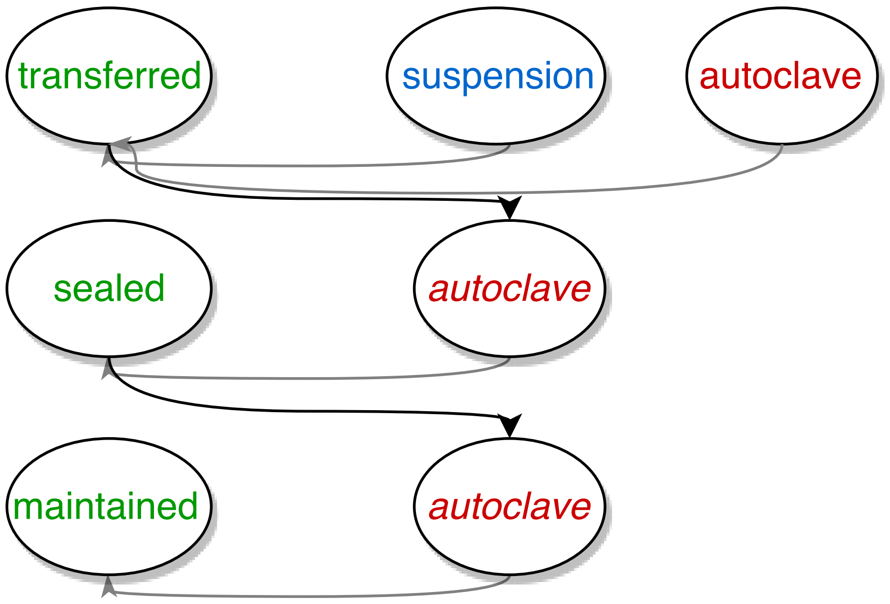

Baseline sequential model:

Edge induction

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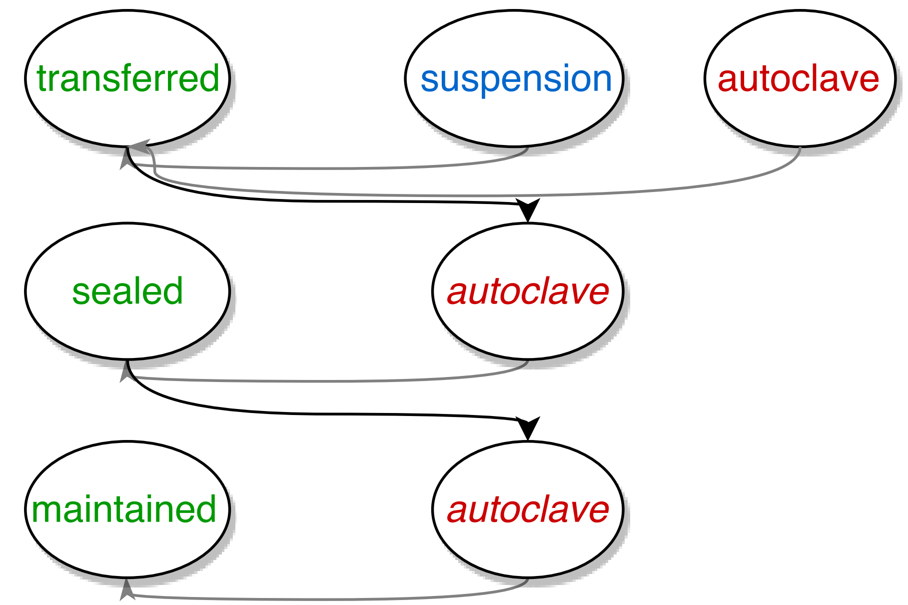

Baseline sequential model:

- Attach each event to the previous event in text.

Edge induction

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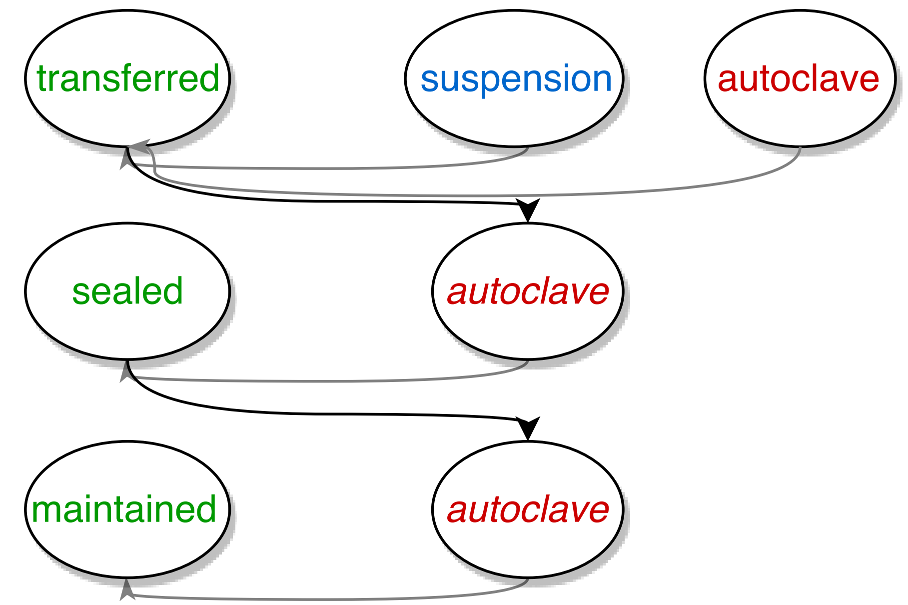

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Unsupervised probabilistic model:

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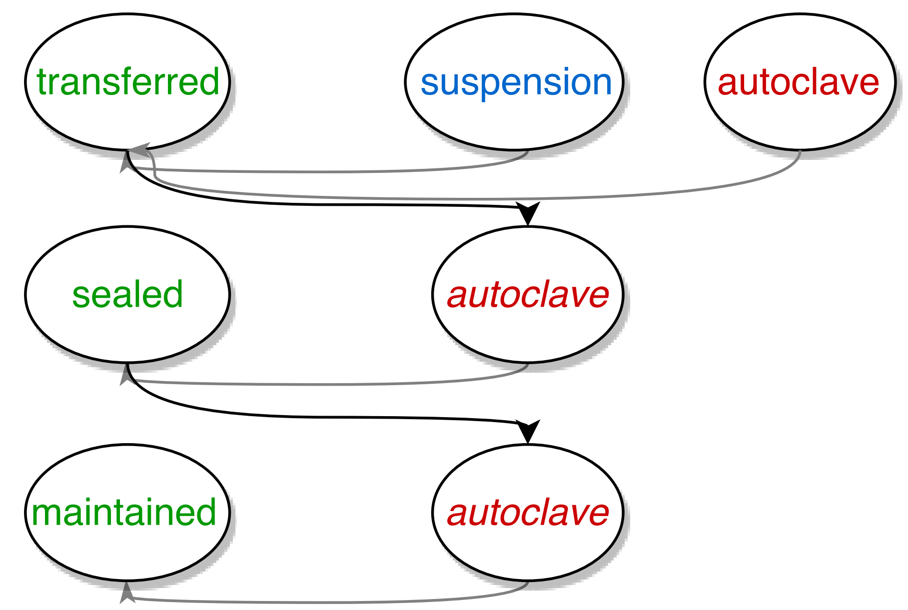

Baseline sequential model:

- Attach each event to the previous event in text.

Unsupervised probabilistic model:

- Define prior over connections: $P(C)$

Edge induction

(**suspension**, **transferred**, **autoclave**)
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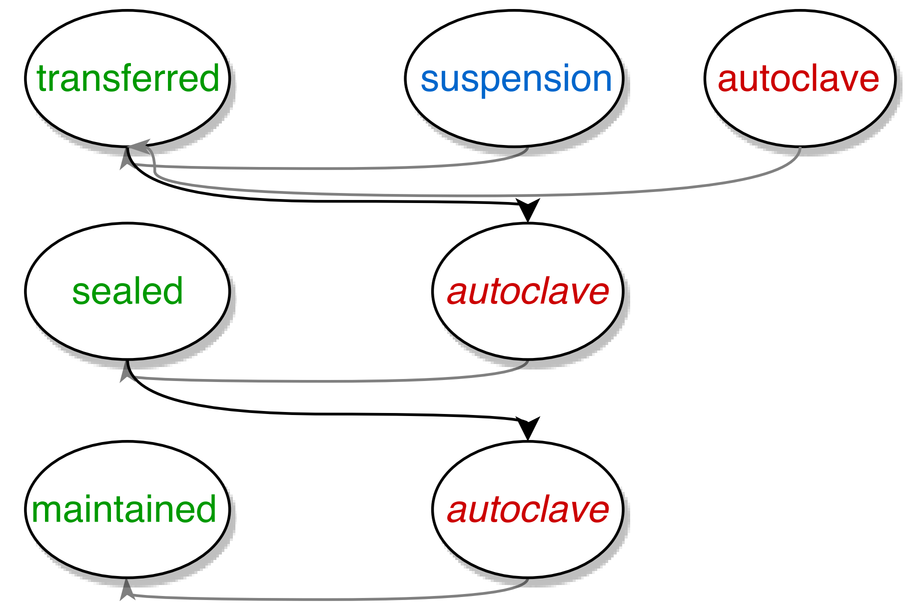

Baseline sequential model:

- Attach each event to the previous event in text.

Unsupervised probabilistic model:

- Define prior over connections: *P(C)*
  - Example: given dependency label, probability of incoming connections?

Edge induction

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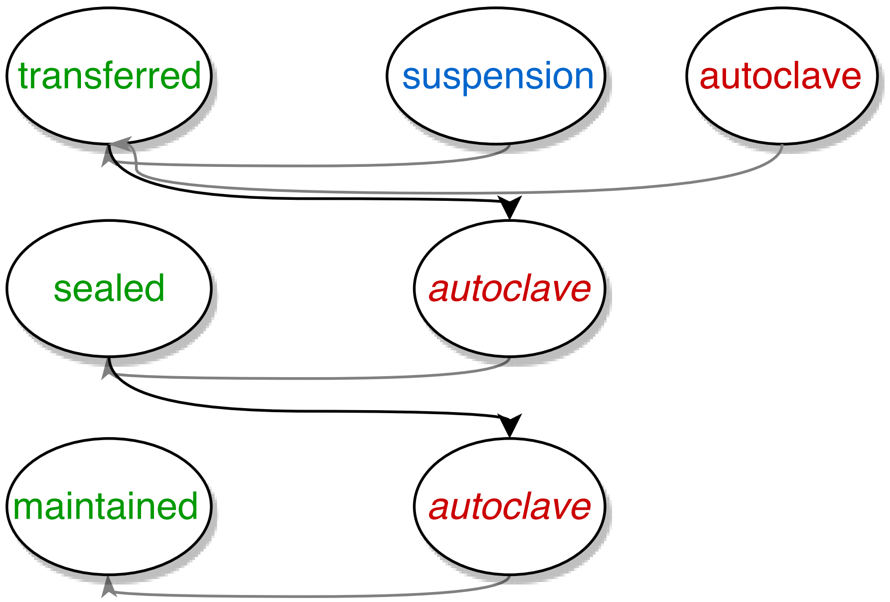

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- Model probability of entities, text given connections: $P(S|C)$

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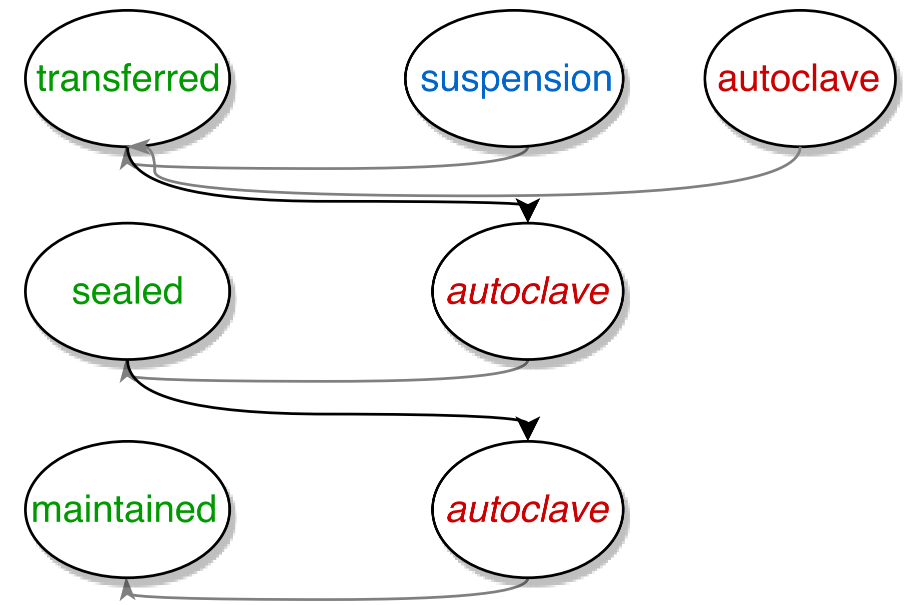

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  - Example: *ozone* more likely to be added while *stirring* than while *heating*

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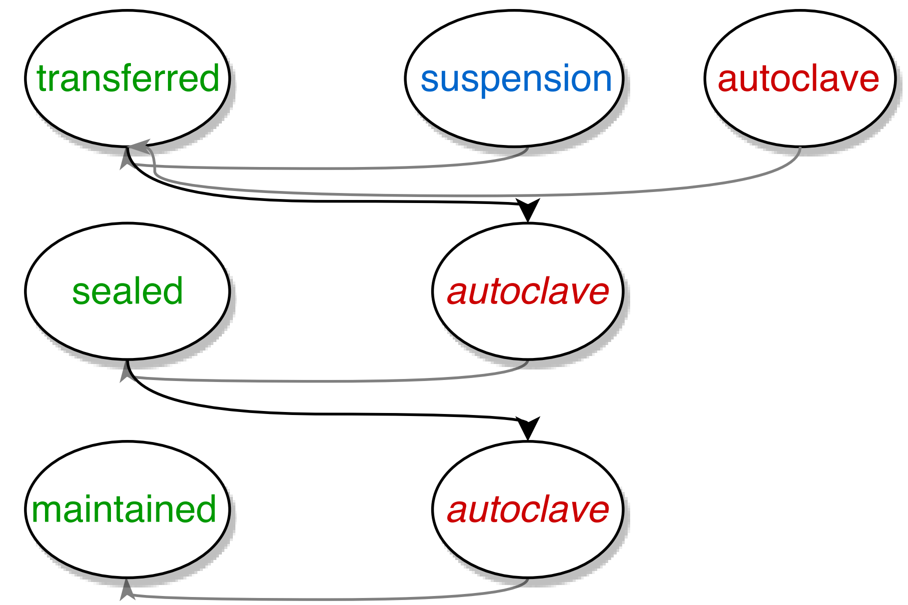

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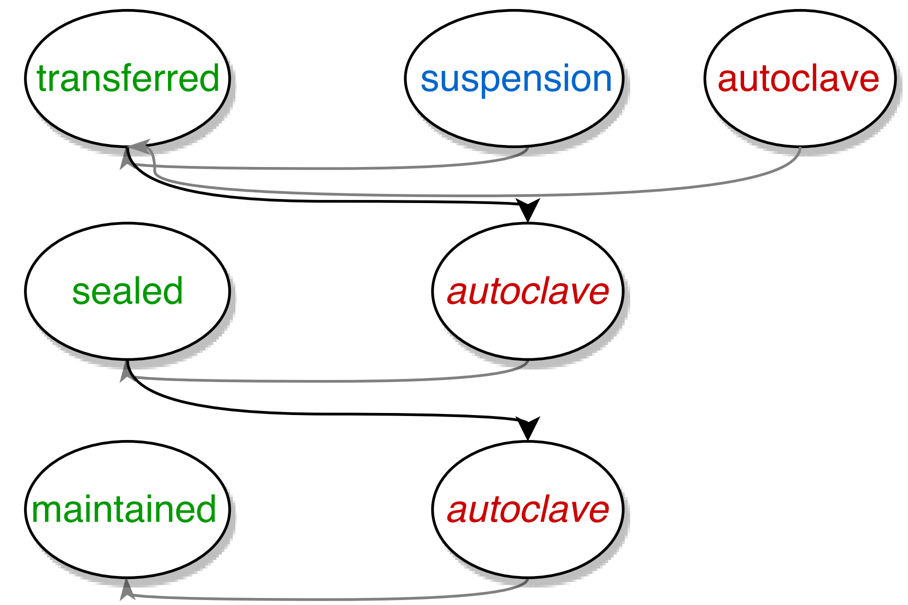

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    - Example: *ozone* more likely to be added while *stirring* than while *heating*
    - Example: *suspension* more likely an intermediate than a raw ingredient
- Maximize $P(S,C) = P(S|C)P(C)$ w/ hard EM

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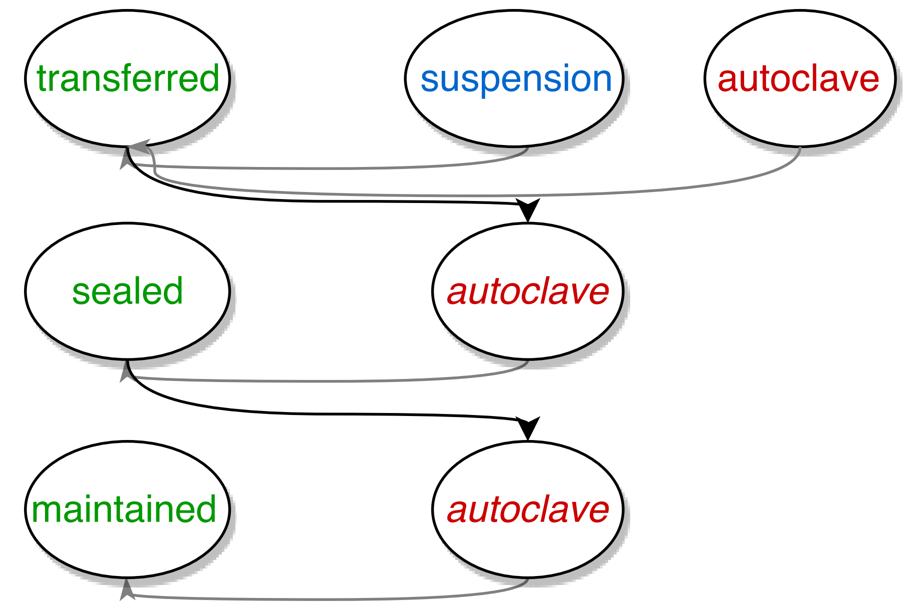

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- Attach each event to the previous event in text.

Unsupervised probabilistic model: [Kiddon et al. 2015, food recipes]

- Define prior over connections: *P(C)*
  - Example: given dependency label, probability of incoming connections?
- Model probability of entities, text given connections: $P(S|C)$
  - Example: *ozone* more likely to be added while *stirring* than while *heating*
  - Example: *suspension* more likely an intermediate than a raw ingredient
- Maximize $P(S,C) = P(S|C)P(C)$ w/ hard EM

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β-MnO_2 nanowires: A novel ozonation catalyst for water treatment

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ABSTRACT

Using $Mn(NO_3)_2$ and ozone as raw materials, β-MnO_2 nanowires with diameters of about 6–12 nm, lengths of 2–5 μm and surface area of 73.54 $m^2\,g^{-1}$ were synthesized by a simple hydrothermal process. The influences of synthesis conditions such as hydrothermal temperature, reaction time and ozone were investigated, and the growth process of β-MnO_2 nanowires was discussed. The catalytic properties of β-MnO_2 nanowires for the degradation of phenol were evaluated. β-MnO_2 nanowires revealed good separability and remarkable catalysis for the degradation of phenol.

1. Introduction

For its great significance, the degradation of organic pollutants in waste water is one of the focuses in water treatment. Kinds of advanced oxidation technologies, such as photo-catalysis, wet-oxidation and catalytic ozonation have been developed. In these oxidation processes, many nanomaterials were proposed as heterogeneous catalysts for their well dispersal and high efficiency. For example, TiO_2 nanomaterials were developed as photo-catalyst [1–5]; other nanomaterials such as ZnO, ZnS, $SrTiO_3$–Fe_2O_3 and Co_3O_4 were used in catalytic ozonation process or photocatalytic methods [6–10]. However, most nanomaterials used currently in water treatment are nanoparticles, which are difficult to be separated from water. This becomes the main limitation for the application of nanomaterials in this field [11–15]. Therefore, it is very desirable to develop novel catalysts with good separability as well as remarkable catalysis for water treatment. One-dimensional (1D) nanostructures such as nanowire and nanofibers are easily sedimentated in water due to their large 1D size and high aspect ratios. Although there are only a few reports about the application of 1D nanostructure in water treatment [16–18], the usage of 1D nanostructure may supply a kind of novel and practical catalysts.

Recently, the synthesis of β-MnO_2 1D nanostructures has attracted much attention for their novel potential properties. It is found that β-MnO_2 is one of the metal oxides which are easier to be present as nanowires [19–23], and β-MnO_2 has potential utility as catalyst, ion-sieves and electrode materials. There are many reports on the usage of β-MnO_2 nanostructure as catalyst [17,18,24–27]. For example, it was found that β-MnO_2 nanomaterials had catalytic performance on H_2O_2 decomposition [17,18,26,27]. It is worth to note that, β-MnO_2 1D nanostructures (nanorods) revealed good catalysis activity on the degradation of dye in water in the presence of H_2O_2 [17,18]. Herein, using $Mn(NO_3)_2$ and ozone as raw materials, β-MnO_2 nanowires were obtained through a facile hydrothermal route. In this method, as an oxidant which cannot introduce any impurities, ozone could be generated instantly and conveniently from air or oxygen, avoiding dangerous factors from the preservation of strong oxidants.

Being a strong oxidation process, catalytic ozonation is efficient and practical for the degradation of organic pollutants [28–30]. In this paper, as-prepared β-MnO_2 nanowires were applied as a catalyst for the degradation of phenol by ozone. β-MnO_2 nanowires revealed remarkable catalysis for the degradation of phenol and the removal of chemical oxygen demand (COD), which denotes a promising prospect in water treatment.

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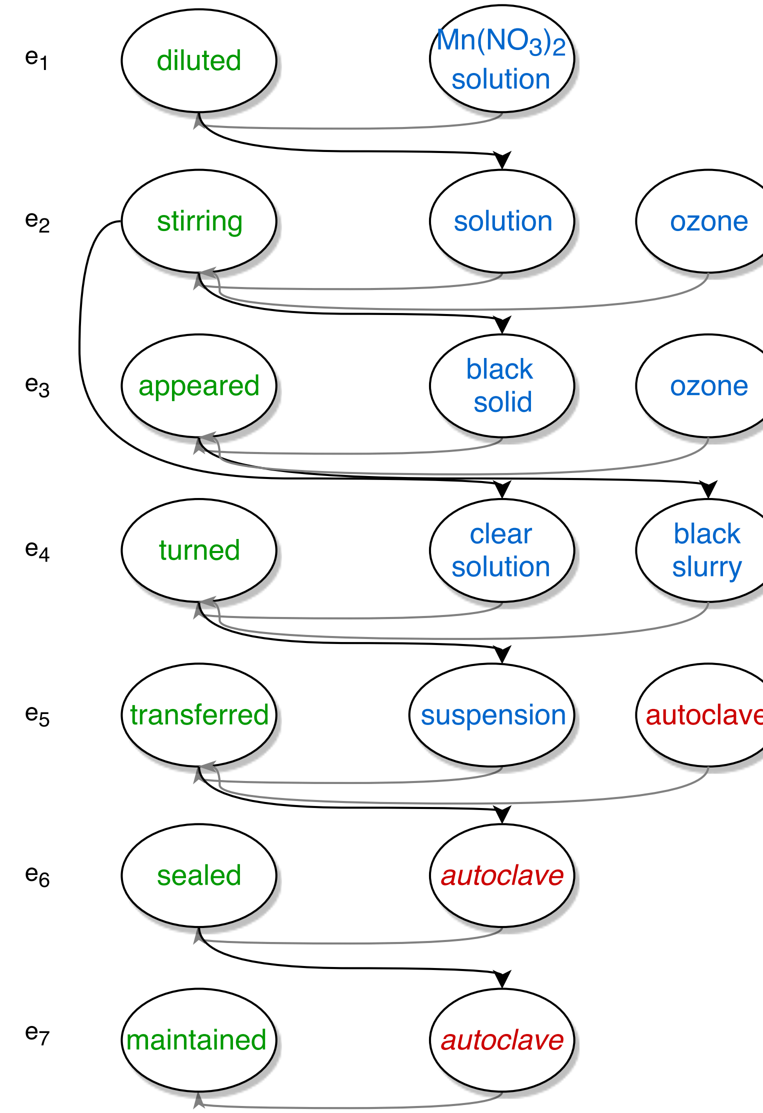
Typical synthesis procedure text

In a typical procedure for the synthesis of β-MnO_2 nanowires, 2.5 mL of 50 wt.% $Mn(NO_3)_2$ solution was diluted to 25.0 mL, and ozone was fed into the bottom of the solution for 30 min under vigorous stirring. With the in-draught of ozone, black solid appeared gradually and the clear solution turned into black slurry finally. Then the suspension was transferred into an autoclave of 48.0 mL, sealed and maintained at 200 °C for 8 h. After this, the autoclave was cooled to room temperature naturally. The resulting solid products were washed with water, and dried at 120 °C for 8 h.



Thank you!