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## **APPENDICES**

## APPENDIX A

### CALCULATION FOR CATALYST PREPARATION

Preparation of TiO<sub>2</sub> nanocrystal via sol-gel (based precipitation) method are shown as follows:

Reagent:      -Titanium ethoxide,  
                          Molecular weight = 284.22  
                          -Cobalt (II) nitrate hexahydrate (Co(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O)  
                          Molecular weight = 290.93

#### Calculation for the preparation of TiO<sub>2</sub> via sol-gel (based precipitation) method

The preparation by using water:alkoxide molar ratio            =     X  
 Let start with titanium ethoxide                                     =     10 g  
    =     10/284.22 mole  
 The amount of water used     =     10/284.22x18(X)  
 The volume of water used     =     10/284.22x18(X)  
 The volume of ethanol used in the first solution with ethanol =     50 ml  
 The volume of ethanol used in the second solution with titanium ethoxide = 50 ml

#### Calculation for the preparation of cobalt loading catalyst (20%Co/TiO<sub>2</sub>)

Based on 100 g of catalyst used, the composition of the catalyst will be as follow:

Cobalt            =     20 g  
 TiO<sub>2</sub>             =     100-20  
                          =     80 g

For 5 g of TiO<sub>2</sub>

Cobalt required        =     5x(20/80)        =     1.25 g

Cobalt 1.25 g was prepared from Co(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O and molecular weight of Co is 58.59

$$\begin{aligned}\text{Co(NO}_3)_2 \cdot 6\text{H}_2\text{O required} &= \frac{\text{MW of Co(NO}_3)_2 \cdot 6\text{H}_2\text{O} \times \text{cobalt required}}{\text{MW of Co}} \\ &= (290.93/58.93) \times 1.25 = 6.17 \text{ g}\end{aligned}$$

## APPENDIX B

### CALCULATION FOR REDUCIBILITY

For supported cobalt catalyst, it can be assumed that the major species of calcined Co-catalysts is  $\text{Co}_3\text{O}_4$ .  $\text{H}_2$  consumption of  $\text{Co}_3\text{O}_4$  is calculated as follows:

$$\text{Molecular weight of Co} = 58.93$$

$$\text{Molecular weight of } \text{Co}_3\text{O}_4 = 240.79$$

#### Calculation of the calibration of $\text{H}_2$ consumption using cobalt oxide ( $\text{Co}_3\text{O}_4$ )

$$\begin{aligned} \text{Let the weight of } \text{Co}_3\text{O}_4 \text{ used} &= 0.01 \text{ g} \\ &= 4.153 \times 10^{-5} \text{ mole} \end{aligned}$$

From equation of  $\text{Co}_3\text{O}_4$  reduction;



$$\begin{aligned} \text{H}_2 &= 4 \text{ Co}_3\text{O}_4 \\ &= 4 \times 4.153 \times 10^{-5} \\ &= 1.661 \times 10^{-4} \text{ mole} \end{aligned}$$

$$\text{Integral area of } \text{Co}_3\text{O}_4 \text{ after reduction} = 396572.5 \text{ unit}$$

Thus the amount of  $\text{H}_2$  that can be consumed at 100% reducibility is  $1.661 \times 10^{-4}$  mole which related to the integral area of  $\text{Co}_3\text{O}_4$  after reduction 396572.5 units.

#### Calculation of reducibility of supported cobalt catalyst

$$\begin{aligned} \text{Integral area of the calcined catalyst} &= X \quad \text{unit} \\ \text{The amount of } \text{H}_2 \text{ consumption} &= [1.661 \times 10^{-4} \times (X)/396572.5] \text{ mole} \\ \text{Let the weight of calcined catalyst used} &= W \quad \text{g} \\ \text{Concentration of Co} &= Y \quad \% \text{wt} \\ \text{Mole of Co} &= [(W \times Y)/58.93] \quad \text{mole} \end{aligned}$$

$$\text{Mole of Co}_3\text{O}_4 = \frac{[(W \times Y)]}{3 \times 58.93} \text{ mole}$$

$$\text{Mole of H}_2 \text{ can be consumed} = \frac{[(W \times Y) \times 4]}{3 \times 58.93} \text{ mole}$$

$$\text{Reducibility (\%)} \text{ of supported Co catalyst} =$$

$$\left\{ \frac{[1.661 \times 10^{-4} \times (X)]}{396572.5} \times 100 \right\} / \left\{ \frac{[(W \times Y) \times 4]}{3 \times 58.93} \right\}$$

## APPENDIX C

CALCULATION FOR TOTAL H<sub>2</sub> CHEMISORPTION  
AND DISPERSION

Calculation of the total H<sub>2</sub> chemisorption and etal dispersion of the catalyst, a stoichiometry of H/Co = 1, measured by H<sub>2</sub> chemisorption is as follows:

Let the weight of calcined catalyst used	=	W	g
Integral area of H <sub>2</sub> peak after adsorption	=	A	unit
Integral area of 45 μl of standard H <sub>2</sub> peak	=	B	unit
Amounts of H <sub>2</sub> adsorbed on catalyst	=	B-A	unit
Concentration of Co (by AAS)	=	C	% wt
Volume of H <sub>2</sub> adsorbed on catalyst	=	45 x [(B-A)/B]	μl
Volume of 1 mole of H <sub>2</sub> at 100°C	=	28.038	μl
Mole of H <sub>2</sub> adsorbed on catalyst	=	[(B-A)/B] x [45/28.038]	μmole
Total hydrogen chemisorption	=	[(B-A)/B] x [45/28.038] x [1/w]	μmole /g of catalyst
	=	N	μmole /g of catalyst
Molecular weight of cobalt	=	58.93	
Metal dispersion (%)	=	[2 x H <sub>2 tot</sub> /g of catalyst x 100] / [No μmole Co <sub>tot</sub> /g of catalyst]	
	=	[2 x N x 100] / [No μmole Co <sub>tot</sub> ]	
	=	[2 x N x 58.93 x 100] / C x 10 <sup>6</sup>	
	=	[1.179 x N] / C	

## APPENDIX D

## CALCULATION AND TRANSFORMATION OF EXAFS DATA

Isolating EXAFS data  $\chi(k)$  from experimental data

The extraction of  $\chi(k)$  from the experimentally obtained  $\mu_{\text{total}}$  follows several consecutive steps, that are visualized in Figure E.1. As defined in equation (E.1),  $\chi$  can be obtained once the atomic absorption is known, by calculating

$$\chi = \frac{\mu_{\text{total}} - \mu_{\text{atomic}}}{\mu_{\text{atomic}}} \quad (\text{E.1})$$

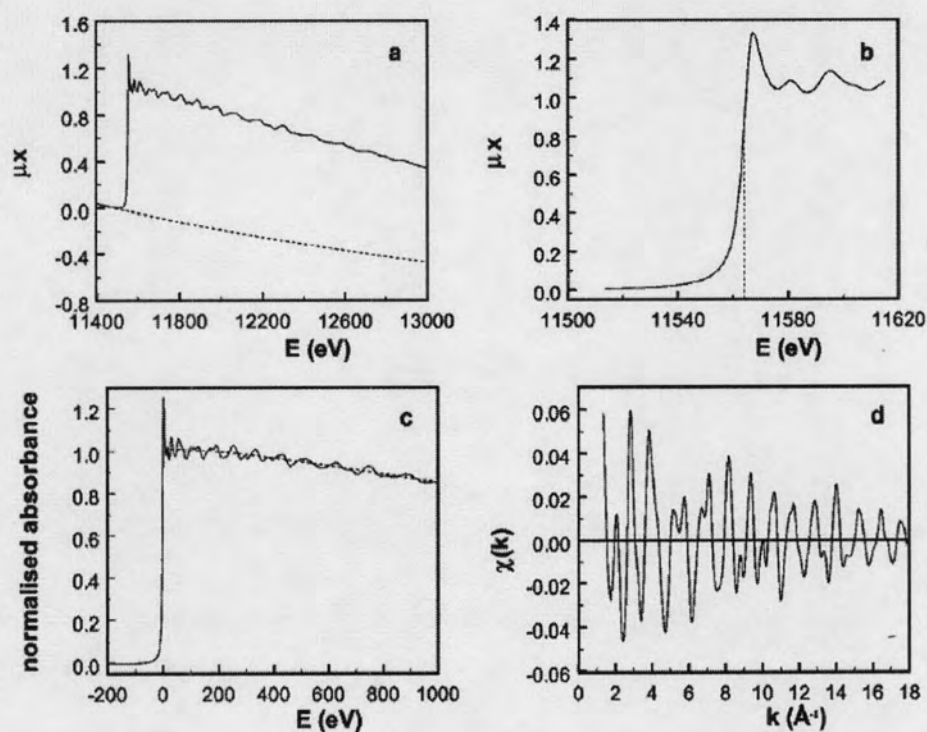


Figure E.1: The details for analyzing EXAFS data



Before  $\mu_{\text{atomic}}$  can be determined, the pre-edge (X-ray absorption before the actual absorption edge occurs) has to be subtracted (Figure E.1(a)). The pre-edge is normally approximated by a modified Victoreen and calculated by extrapolation of the pre-edge region in the data. After the pre-edge subtraction the edge energy (e.g.,  $E_{\text{edge}}$ ) has to be defined (Figure E.1(b)). The value of the edge energy is used to calculate  $k$  ( $\text{\AA}^{-1}$ ) as given in (E.2).

$$\lambda = 2\pi/k, \tag{E.2}$$

$$k = \sqrt{\left(\frac{8\pi^2m}{h^2}\right)(h\nu + E_0 - E_{\text{edge}})},$$

with  $k$  the wave-vector,  $m$  the electron mass and  $h$  Planck's constant.

The choice for this energy is rather arbitrary. The inflection point (i.e., the maximum in the first derivative of the absorption edge) is generally considered as a systematic choice. However, the presence of resonances or electronic excitations can cover up the exact position of  $E_{\text{edge}}$ . To avoid this complexity, the position of the half height (0.5–0.6) of the normalised edge is often chosen as  $E_{\text{edge}}$ . The inner potential,  $E_0$ , is often chosen to be zero.

The atomic background ( $\mu_{\text{atomic}}$ ) after the absorption edge has to be determined (Figure E.1(c)), normally using a cubic spline:

$$\sum_{i=1}^{\text{NPTS}} \frac{(\mu x_i - BCK_i)^2}{e^{-WEk_i^2}} \leq \text{SM}. \tag{E.3}$$

The cubic spline consists of four parameters that define the spline function: SM (smoothing parameter),  $W$  (weighting factor) and the start and end energy that determine the number of points. The more data points available, the better the spline will be defined. The background is optimized using several criteria, of which the most important is not to remove any of the oscillating information from your data.

Since it has been shown recently that important information can be obtained from the atomic XAFS contribution, both  $\chi_{EX}$  and  $\chi_{AX}$  have to be separated from the free atomic background. This can be accomplished by a procedure, described in detail in the following paper of this volume.

Before  $\chi(k)$  can be obtained, the total absorption as obtained from experiment has to be normalised per absorber atom. Generally, spectra are normalised by division of the absorption data by the edge-step at 50 eV after the absorption edge (Figure E.1(c)). Finally,  $\chi(k)$  is calculated according to (11) (Figure E.1(d))

#### Fourier transformation of EXAFS data

Sayers et al. have shown in 1971 that Fourier transformation of  $\chi(k)$  results in a radial distribution function (figure E.2). The Fourier transformation is defined by

$$FT(R) = \frac{1}{\sqrt{2\pi}} \int_{k_{\min}}^{k_{\max}} k^n \chi(k) e^{i2kR} dk. \quad (E.4)$$

The radial distribution function is defined in  $R$ -space (e.g., distance from the absorber atom). The distance found in the Fourier transformation is about 0.2–0.5 Å shorter than the actual distance due to the energy dependence of the phase factors in the sine function (see equation (9)). The Fourier transform can be taken with different  $k$  weightings (multiplication by  $kn$ ).

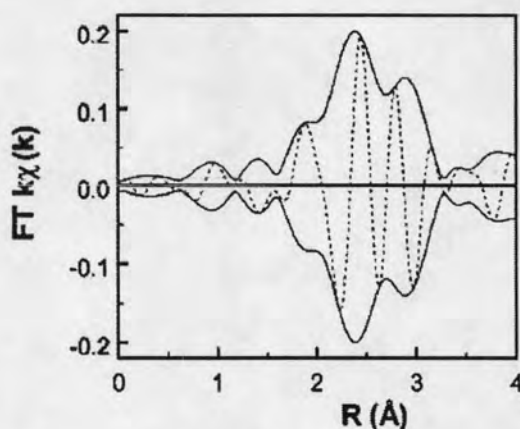


Figure E.2: Radial distribution function

This can be used to distinguish between high and low  $Z$  scatterers around the absorber atom. An element with low mass (like oxygen) will scatter mainly at lower  $k$ -values, while platinum (high mass) will scatter significantly at higher  $k$ -values. Weighting of the Fourier transformation will, therefore, emphasise the important scatterer in a specific region.

Since the Fourier transform is a complex function, both real and imaginary parts are obtained. The envelope (absolute part) of the Fourier transform is defined by

$$\text{absolute part} = \sqrt{\text{Im}^2 + \text{Re}^2}. \quad (\text{E.5})$$

Figure E.2 shows both the absolute and imaginary part of the Fourier transform for Pt foil. The absolute part is determined mainly by the number of neighbours and disorder. The imaginary part is very useful in the analysis of EXAFS data for an accurate determination of the absorber–scatterer distance and for the discovery of unknown contributions when analysing EXAFS data.

#### Fourier filtering of EXAFS data

In addition to forward Fourier transformation, coordination shells can be isolated (filtered) using the inverse Fourier transformation, which results in a  $\chi_j(k)$  function for that specific shell. This method can be very useful in analysing data or obtaining standards for phase shifts and backscattering amplitudes from reference compounds that are needed in EXAFS data analysis. Figure E.3(a) demonstrates the Fourier filtering of the first Pt–Pt shell of Pt foil. The forward Fourier transform is taken with a  $k^3$  weighting from  $k = 1.9$  to  $18.6$ . The first-shell Pt–Pt peak is Fourier filtered from  $R = 1.6$  to  $3.2 \text{ \AA}$ . The isolated firstshell Pt–Pt EXAFS is plotted in figure E.3(b) with a dotted line superimposed onto the original EXAFS function (solid line). Some Fourier filtering errors occur over a region of about  $\Delta k = 1 \text{ \AA}^{-1}$  at the start and the end of the isolated first-shell Pt–Pt EXAFS. This region should be avoided in analysing Fourier filtered data. The Fourier transforms ( $k^3$ ,  $\Delta k = 2.6\text{--}17.8 \text{ \AA}^{-1}$ ) of the raw EXAFS data and the isolated first-shell data are shown in figure E.3(c) with a solid and dotted lines, respectively.

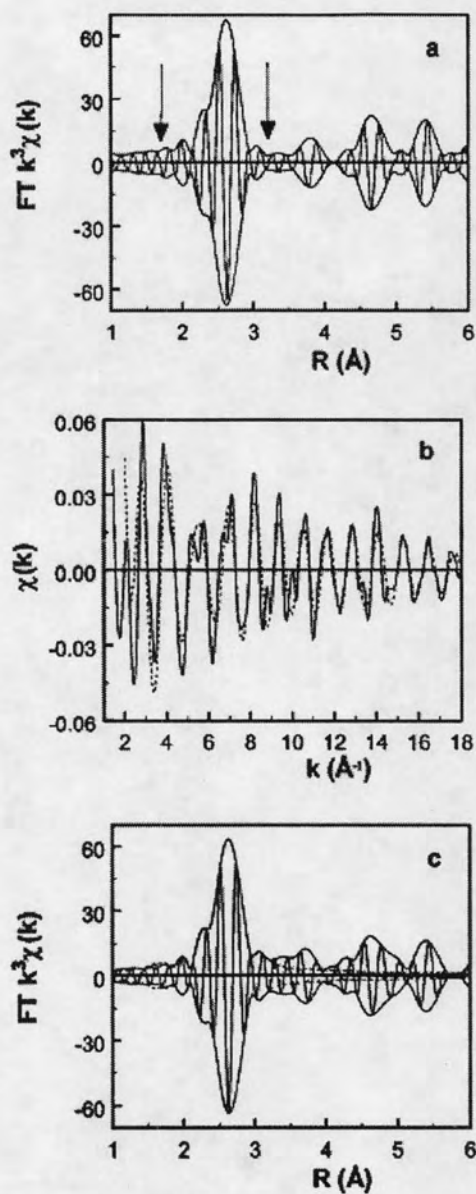


Figure E.3: Isolation of one coordination cell

There are no differences observed between the first shell in both Fourier transforms, which proves that Fourier filtering errors can be completely avoided by using a slightly shorter range in  $k$  space than applied in the original forward Fourier transformation used in the filtering procedure.

### Phase shifts and backscattering amplitudes derived from EXAFS data obtained from reference compounds

It can be seen that many parameters determine the final  $\chi(k)$  function. In addition to the coordination number, distance and disorder, the backscattering amplitudes and phase shifts have to be known. On first sight, this seems to make data analysis rather complicated as so many parameters are unknown. However, it was found that the backscattering amplitude and phase shifts are transferable from one compound to the other, if the same absorber–backscatterer pair is involved. Thus if a supported platinum catalysts is studied, a Pt foil can be used as a reference compound for Pt–Pt scattering amplitude and phase shifts. A compound can only be used as a reference if it has a uniform structure which is exactly known, for example from X-ray diffraction. The X-ray absorption spectrum is taken for this compound, and  $\chi(k)$  is isolated according to the above described procedure. Then the Fourier transform of the data is taken and one coordination shell is specified to be isolated (see figure E.3(a)). This will lead to

$$\chi_{\text{ref}}(k) = A_{\text{ref}}(k) \sin [\Phi_{\text{ref}}(k)] \quad (\text{E.6})$$

with  $A_{\text{ref}}(k)$  and  $F_{\text{ref}}(k)$  as known functions of  $k$ . The reliability range in  $k$ space of  $A_{\text{ref}}(k)$  and  $F_{\text{ref}}(k)$  is mainly determined by the  $k$  interval (from  $k_{\text{min}}$  to  $k_{\text{max}}$ ) of the forward Fourier transform used in the Fourier filtering procedure. The reliability range of  $A_{\text{ref}}(k)$  and  $F_{\text{ref}}(k)$  can generally be taken from  $k_{\text{min,rel}} = k_{\text{min}} + 1$  to  $k_{\text{max,rel}} = k_{\text{max}} - 1$ .

Since the coordination number and distance are precisely known (for example  $N_{\text{Pt–Pt}} = 12$  at  $2.77 \text{ \AA}$  in a Pt foil) these can be used to extract a semi-backscattering amplitude ( $F_0(k)$ ) and total phase shift for the reference compound. The obtained  $F_0(k)$  is not the real backscattering amplitude  $F(k)$ , as it also contains the  $S^2_0$ , Debye–Waller factor ( $\sigma$ ) and electron mean free path ( $\lambda$ ).  $S^2_0$  and  $\lambda$  are also considered to be transferable from a reference compound. One can define

$$F'(k) = S^2_0 e^{-2R/\lambda} e^{-2k^2\sigma^2} F(k),$$

Lead to

$$F'_{\text{ref}}(k) = \frac{A_{\text{ref}}(k)kR_{\text{ref}}^2}{N_{\text{ref}}}. \quad (\text{E.7})$$

Equation E.6 also leads to

$$\varphi_{\text{ref}}(k) = 2kR_{\text{ref}} - \Phi_{\text{ref}}(k). \quad (\text{E.8})$$

The phase shift  $\varphi_{\text{ref}}(k)$  and the backscattering amplitude  $F'_{\text{ref}}(k)$  can now be determined using the experimentally determined functions  $A_{\text{ref}}(k)$  and  $F_{\text{ref}}(k)$  and the known values of  $N_{\text{ref}}$  and  $R_{\text{ref}}$ . They can be used to analyse the EXAFS function of a sample with unknown structure. In practice, the reliability range for  $\varphi_{\text{ref}}(k)$  and  $F'_{\text{ref}}(k)$  obtained from reference EXAFS data of good signal to noise ratio is from  $k_{\text{min}} = 3.5/4$  to  $k_{\text{max}} = 12/15$ .

### Data analysis, obtaining R, N and $\Delta\sigma^2$ , k-space and R-space fitting

Consistent with equations (E.7) and (E.8), the function that has to be minimised in the data analysis is

$$\chi_{\text{exp}}(k) = \sum_{j=1}^{\text{shells}} \frac{N_j}{k'_j R_j^2} e^{-2k'_j \Delta\sigma_j^2} F'_{\text{ref}}(k'_j) \times \sin [2k'_j R_j + \varphi_{\text{ref},j}(k'_j)], \quad (\text{E.9})$$

where  $\Delta\sigma^2$  is the Debye–Waller factor relative to that of the reference compound. Further,  $k\theta$  is a corrected wave vector to account for the difference in inner potential between the sample and the reference compound ( $\Delta E_0$ ):

$$k' = \sqrt{k^2 + \frac{2m_e}{\hbar} \Delta E_0}. \quad (\text{E.10})$$

Several papers have been published discussing the number of parameters that can be extracted from an EXAFS spectrum. The available data-range determines the number of free parameters that may be optimised according to the Nyquist theorem:

$$\text{number of free parameters} = \frac{2\Delta k \Delta R}{\pi} + 2. \quad (\text{E.11})$$

When fitting the full EXAFS spectrum (full  $\Delta k$  and  $\Delta R$  range), the maximum number of independent parameters indicated from equation (20) can be less than the number of parameters needed to fit the total structure. This is because one has to include all shells in the data analysis, as well as all multiple scattering paths. One can avoid this problem by analysing only one or two particular co-ordination shells (i.e., choosing a small range of  $\Delta R$  where it is known that just one or two shells contribute). Of course, equation (20) indicates that the number of free parameters must be reduced when limiting  $\Delta R$ , however, the number of parameters required to fit just one or two shells is now also very much smaller.

The least squares fitting can be done in either  $k$ -space or in  $R$ -space. When fitting in  $k$ -space one minimizes the variance:

$$k^n \text{ variance} = \frac{\int [k^n (\chi_{\text{model}}(k) - \chi_{\text{exp}}(k))]^2 dk}{\int [k^n \chi_{\text{exp}}(k)]^2 dk} \times 100, \quad (\text{E.12})$$

where the  $\chi_{\text{exp}}(k)$  in equation (E.11) is in most cases the  $\chi$  obtained from the reverse transform of the chosen  $\Delta R$  region of the full  $\text{FT}_{\text{exp}}(R)$ . This process is known as Fourier filtering to eliminate the extra shells from the  $\chi(k)$  as discussed above. In  $R$ -space the variance between model and experiment are calculated for the imaginary and absolute parts by the expression

$$k^n \text{ variance} = \frac{\int [k^n (\text{FT}_{\text{model}}(R) - \text{FT}_{\text{exp}}(R))]^2 dR}{\int [k^n \text{FT}_{\text{exp}}(R)]^2 dR} \times 100, \quad (22) \quad (\text{E.13})$$

where the integral over  $R$  is over just the limited chosen  $\Delta R$  region. The variance or fit index should be below 1% to have a good fit of the experimental data in either case.

The difference between fitting in  $k$ -space and  $R$ -space is rather subtle, but very important, and the advantages lie with the  $R$ -space fitting. In  $k$ -space one has to reverse Fourier transform the experimental  $\chi(k)$  over the chosen  $\Delta R$  region in the Fourier filtering process. This introduces truncation errors at the outer regions of the data as discussed above, thereby reducing the reliable  $\Delta k$ -range. Taking the Fourier

transform in either direction (forward or reverse) introduces truncation errors, but this truncation effect is not a problem in  $R$ -space fitting, because the chosen  $\Delta R$  region is much smaller than the total  $R$  range anyway. Secondly, the noise build up problem is minimized in  $R$ -space fitting, since the model function has no noise in it. However, in  $k$ -space fitting, one has to forward, then reverse the Fourier transform process on the experimental data. Although this eliminates the high-frequency noise and higher shells, it can increase the relative magnitude of the low-frequency noise. Thirdly, and perhaps most important, in  $k$ -space fitting the variance defined in equation (E.11) has many maxima and minima. This is because the  $\chi(k)$  function is an oscillatory function so that if the wavelength of the model and experimental  $\chi$  are not very similar, the two functions go in and out of phase, introducing many hills and valley in the variance function. Of course the  $FT(R)$  in the chosen  $\Delta R$  range has normally just one maximum in it. Thus the least-squares iterative process is much more stable and the problem of converging to a relative minimum rather than the true minimum is much less probable in  $R$ -space fitting.

There are several ways to judge the quality of the fit after achieving convergence. One should always compare the model fit and the experimental data both in  $R$ - and  $k$ -space. In  $R$ -space, both the imaginary part and the amplitude of the Fourier transform is used in fitting the spectra. The amplitude depends on the coordination number and disorder, whereas the imaginary part is mainly determined by the interatomic distance and the inner potential correction. Thus the imaginary part is very sensitive for judging the quality of the fit, since a misfit shows up immediately in the appearance of wrong nodes in the imaginary part of the Fourier transform. Moreover, comparison in  $R$ -space easily reveals the effect of overlapping shells. Comparison in  $k$ -space even more dramatically reveals errors in the fit if the wavelength or amplitude of the model  $\chi(k)$  is not the same as the experimental one.

The fit quality can also be examined mathematically as defined by the Goodness of Fit function:

$$\text{Goodness of Fit} = \varepsilon_v^2 = \frac{P}{\text{NPTS}(P-p)} \sum_i^{\text{NPTS}} \left( \frac{\chi_{\text{exp}}^i - \chi_{\text{model}}^i}{\sigma_{\text{exp}}^i} \right)^2. \quad (\text{E.14})$$



Here  $P$  is the total number of free parameters,  $p$  the number of free parameters that have been refined, and NPTS is the actual number of points in the  $k$ -range used for analysis,  $\chi_{\text{exp}}$  is the standard deviation for each data point, obtained by averaging several scans of one experiment, which improves the signal to noise ratio of the final  $\chi(k)$ .

Often the standard deviation in the experimental data is very small, as it only represents statistical errors. As a result, the  $\varepsilon^2 v$  values are extremely high. In that case systematic errors (e.g., experimental uncertainty) should be added to those standard deviations obtained by averaging scans. When the structural error is not known, variances in both  $k$ - and  $R$ -space less than 1% are indicative of model spectra that fit the experimental data closely. To check whether one model describes the data better than a second model, a so-called  $F$ -test can be applied. In this way, a probability percentage can be obtained for the likelihood of a model. However, when data analysis is performed in  $R$ -space, without using the complete  $R$ -range, no useful information can be obtained from the  $F$ -test, as it is calculated in  $k$ -space over the whole available range.

The XDAP-program also provides a possibility to calculate statistical errors in and correlation between parameters. The calculations are based on the experimental standard deviation, which in many cases is too low to account for systematic errors. This results in estimated or calculated (mathematical) errors in the parameters that are too small (often less than 0.1%). Recently, a study was published on the reliability of parameters obtained by XAFS data-analysis. Based on their results, the errors in many instances are estimated to be 5% in coordination number ( $N$ ), 1% in distance ( $R$ ), 5% in Debye–Waller factor ( $\Delta\sigma^2$ ) and 10% in inner potential correction ( $E0$ ).

## APPENDIX E

### CALCULATION OF CO CONVERSION, REACTION RATE

The catalyst performance for the CO hydrogenation was evaluated in terms of activity for CO conversion reaction rate and selectivity.

Activity of the catalyst performed in term of carbon monoxide conversion and reaction rate. Carbon monoxide conversion is defined as moles of CO converted with respect to CO in feed:

$$\text{CO conversion (\%)} = 100 \times \frac{[\text{mole of CO in feed} - \text{mole of CO in product}]}{\text{mole of CO in feed}} \quad (\text{i})$$

where mole of CO can be measured employing the calibration curve of CO

$$\text{mole of CO} = (\text{area of CO peak from integrator plot on GC-8A}) \times 3 \times 10^{-11} \quad (\text{ii})$$

Reaction rate was calculated from CO conversion that I as follows:

Let the weight of catalyst of catalyst used	=	W	g
Flow rate of CO	=	2	cc/min
Reaction time	=	60	min
Weight of CH <sub>2</sub>	=	14	g
Volume of 1 mole of gas at 1 atm	=	22400	cc
Reaction rate (g CH <sub>2</sub> /g of catalyst/h) = $\frac{[\% \text{ conversion of CO}/100] \times 60 \times 14 \times 2}{W \times 22400}$ (iii)			

**APPENDIX F****LISTS OF PUBLICATIONS**

1. Impact of  $\text{Ti}^{3+}$  present in titania on characteristics and catalytic properties of the  $\text{Co}/\text{TiO}_2$  catalyst, **Industrial and Engineering Chemistry Research** 44 (2005): 6599.
2. Effect of calcination condition on surface structure of titania nanocrystal photocatalyst, **Studies in Surface Science and Catalysis** 159 (2006): 717.
3. Control of  $\text{Ti}^{3+}$  surface defect on  $\text{TiO}_2$  nanocrystal using various calcination atmosphere as the first step for surface defect creation and its application in photocatalysis, **Applied Surface Science**, 253 (2007): 3849.
4. Effect of surface sites of  $\text{TiO}_2$  support on the formation of cobalt-support compound in  $\text{Co}/\text{TiO}_2$  catalyst, **Catalysis Communication**, 8 (2007) 1772.

## BIOGRAPHY

Mr. Kongkiat Suriye was born on March 23, 1981 in Bangkok, Thailand. He received the Bachelor's Degree of Chemical Engineering from the Department of Chemical Engineering, Faculty of Engineering, King Mongkut's University of Technology, Thonburi in May 2003, He continued his Doctoral degree in Department of Chemical Engineering, Faculty of Engineering, Chulalongkorn University in June 2003.

His research works have been accepted and/or submitted for the publication as listed below:

1. Impact of  $Ti^{3+}$  present in titania on characteristics and catalytic properties of the  $Co/TiO_2$  catalyst, **Industrial and Engineering Chemistry Research** 44 (2005): 6599.
2. Effect of calcination condition on surface structure of titania nanocrystal photocatalyst, **Studies in Surface Science and Catalysis** 159 (2006): 717.
3. Control of  $Ti^{3+}$  surface defect on  $TiO_2$  nanocrystal using various calcination atmosphere as the first step for surface defect creation and its application in photocatalysis, **Applied Surface Science**, 253 (2007): 3849.
4. Effect of surface sites of  $TiO_2$  support on the formation of cobalt-support compound in  $Co/TiO_2$  catalyst, **Catalysis Communication**, 8 (2007) 1772.
5. Study on the main parameter controlling the crystal growth rate of the  $TiO_2$  nanocrystal during high temperature, **Journal of Crystal Growth**, submitted.
6. A new method creating the surface defect coinciding with the preparation of the anatase  $TiO_2$  nonocrystal in the first step, **Langmuir**, submitted.
7. Probing surface defect on  $TiO_2$  with  $H_3Re_3(CO)_{12}$ : Spectroscopic Characterization of surface species, **The Journal of American Chemical Society**, submitted.

